EPA/ROD/R03-00/014
2000

EPA Superfund
Record of Decision:

NAVAL AIR DEVELOPMENT CENTER (8 WASTE AREAS)
EPA ID: PA6170024545
OU 12
WARMINSTER TOWNSHIP, PA
09/27/2000

DECLARATION

Department of the Navy

Record of Decision for OU-1A

Naval Air Warfare Center

SITE NAME AND LOCATION

Naval Air Development Center

Area A Groundwater (Operable Unit 1A)

Warminster, Pennsylvania

CERCLIS ID # PA6170024545

STATEMENT OF BASIS AND PURPOSE

This decision document presents the selected final remedy for contaminated groundwater attributable to releases from Area A (hereafter referred to as "Area A groundwater") at the Naval Air Development Center (NADC) ("the Site") in Warminster, Pennsylvania. This determination has been made in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by Superfund Amendments and Reauthorization Act of 1986 (SARA), and to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). This determination is the final remedy for Area A groundwater, which has been designated Operable Unit 1A (OU-1A). This decision is based on the Administrative Record file for the Site.

In 1993, the Site was renamed the Naval Air Warfare Center (NAWC) Aircraft Division. NAWC was disestablished on September 30, 1996 and is targeted for transfer to the private sector.

The Commonwealth of Pennsylvania, as represented by the Pennsylvania Department of Environmental Protection (PADEP), concurs with the selected final remedy for OU-1A at the Site.

ASSESSMENT OF THE SITE

The response action selected in this Record of Decision (ROD) is necessary to protect the public health, welfare, or the environment from actual or threatened releases of hazardous substances into the environment.

DESCRIPTION OF THE SELECTED FINAL REMEDY

An Interim Remedy Record of Decision for OU-1 (groundwater contamination attributable to Areas A and B) was issued in September 1993 and selected pumping and treatment of groundwater to limit groundwater contaminant migration and to initiate aquifer restoration. The interim remedy for Area A groundwater (OU-1A) has been constructed and is operational at this time.

Soils within Area A are being addressed under OU-9. Removal actions addressing Area A soils were undertaken by the Navy between 1996 and 1999. These actions consisted of the excavation and offsite disposal of soils from Area A. In June 2000, the Navy and EPA issued a ROD which found that no further action was necessary to address soils in Area A. Data gathered during these investigations and removal actions have not identified a residual source of contamination in the soils which would constitute a principal

threat as defined by the NCP. Groundwater data collected during the installation and operation of monitoring and extraction wells, however, has identified the presence of dense non-aqueous-phase liquid (DNAPL) contaminants in bedrock within Area A. This DNAPL is a principal threat waste as defined by the NCP.

This DNAPL contains trichloroethene (TCE) and potentially carbon tetrachloride (CCl_4) and/or tetrachloroethene(PCE) at saturation levels within the bedrock fracture network and, to a lesser degree, within the intergranular pores of the rock. Monitoring and extraction wells drilled within and adjacent to Area A have delineated the DNAPL zone. This zone consists of an area approximately 80 feet in diameter at a depth from the water table to 70 feet below ground surface.

This DNAPL zone contains groundwater that is technically impracticable to restore to beneficial use. Because of the high concentrations of TCE and potentially CCl_4 and/or PCE, this area has been designated for a Technical Impracticability Waiver (TIW). The area where remedial action clean-up goals have been determined to be impracticable to attain is referred to as the TI Zone. Federal and state ARARs associated with the restoration of groundwater to drinking water standards for these specific contaminants are waived within this TI Zone. The waiver does not apply to the dissolved phase contaminant plume or to any other compounds within the TI Zone. The TIW and this ROD require that contamination associated with the TI Zone and the DNAPL present within the TI Zone be contained. The TI Zone and the specific components of the selected remedy for Area A groundwater are defined in this ROD.

The major components of the selected final remedy for OU-1A are as follows:

Component 1: Existing Groundwater Extraction System
This component shall use the existing interim remedy Area A groundwater extraction system to contain the source area (DNAPL zone), contain/remediate the source area groundwater dissolved contaminant plume and remediate a portion of the downgradient groundwater contaminant plume. The existing pumping of Warminster Municipal Authority Well No. 26 (WTMA 26) shall capture and remediate the balance of the downgradient groundwater contaminant plume.

Component 2: Existing Groundwater Treatment System
This component shall consist of continued treatment of extracted Area A groundwater in the existing interim remedy groundwater treatment system (GWTS). This component shall include operation and maintenance of the existing system and monitoring of its performance.

Component 3: Existing Discharge of Treated Groundwater
This component shall consist of the continued discharge of the treated Area A groundwater from the existing GWTS to an existing interim remedy chlorine contact chamber and to Outfall 001 through the existing pipeline to Little Neshaminy Creek. This component will also include regular monitoring and reporting of the quality of discharged water.

Component 4: Institutional Controls
Institutional controls shall be implemented to prevent the use of Area A groundwater as long as it presents an unacceptable risk and to protect the integrity and effectiveness of the extraction well network. The institutional controls addressing current NAWC property shall consist of restrictions to be included in deeds entered into for transfer of the property. The controls for current off-base property in Warminster Township will consist of the continued enforcement of a municipal ordinance that regulates well drilling. The controls for current off-base property in Ivyland Borough will consist of enforcement of a well drilling regulation ordinance to be promulgated by Ivyland Borough.

Component 5: Groundwater Monitoring
Groundwater monitoring shall consist of regularly collecting water level measurements and analyzing groundwater samples both from within and outside the contaminant plume to assess progress of remediation and to evaluate contaminant migration.

STATUTORY DETERMINATIONS

The selected final remedy for OU-1A is protective of human health and the environment, complies with or waives Federal and Commonwealth of Pennsylvania requirements that are legally applicable or relevant and appropriate to the remedial action, is cost effective, and utilizes permanent solutions and alternative treatment or resource recovery technologies to the maximum extent practicable.

The selected final remedy for OU-1A also satisfies the statutory preference for treatment as a principal element of the remedy which permanently reduces the toxicity, mobility, or volume of hazardous substances, pollutants, or contaminants to the maximum extent practicable.

Because the selected final remedy will result in contaminants remaining in Area A groundwater above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted within 5 years after initiation of the remedial action to ensure that the remedy is, or will be, protective of human health and the environment.

ROD Data Certification Checklist

The following information is included in the Decision Summary section of this ROD. Additional information can be found in the Administrative Record for NAWC.

- Chemicals of concern (COCs) and their respective concentrations
- Baseline risk represented by the COCs
- Cleanup levels established for COCs and the basis for the levels
- How source areas, DNAPL or TI Zone, are addressed.
- Current and reasonably anticipated future land use assumptions and current and potential future beneficial uses of Area A groundwater used in the baseline risk assessment and ROD.
- Potential land and groundwater uses that will be available at the Site as a result of the selected remedy.
- Estimated capital, operation and maintenance (O&M), and total present worth costs; discount rate; and the number of years over which the remedy cost estimates are projected
- Decisive factors that led to selecting the remedy (i.e., how the selected remedy provides the best balance of tradeoffs with respect to the balancing and modifying criteria)

Date 4/26/00

Orlando J. Monaco
BRAC Environmental Coordinator
Naval Air Warfare Center
Warminster, Pennsylvania

Date 9/27/00

Abraham Ferdas, Director
Hazardous Site Cleanup Division
U.S. EPA - Region III

DECISION SUMMARY

I. SITE NAME, LOCATION, AND DESCRIPTION

The former Naval Air Development Center is located in Warminster Township and Ivyland Borough, Bucks County, Pennsylvania. The National Superfund electronic database identification number for the Naval Air Development Center is PA6170024545. The Naval Air Development Center was renamed the Naval Air Warfare Center (NAWC) Aircraft Division in January 1993 and was disestablished on September 30, 1996, in response to the requirements of the Base Realignment and Closure Act (BRAC). The Department of the Navy is the lead agency and EPA the support agency for CERCLA activities at NAWC. The Department of Defense is the source of cleanup monies for NAWC. Groundwater underlying Area A at NAWC has been identified as Operable Unit 1A at NAWC and is addressed by this ROD. Groundwater underlying Area A (or "Area A groundwater") is defined as groundwater potentially impacted by contamination attributable to releases within NAWC Area A which contains Sites 1, 2 and 3 and an Impoundment Area. Sites 1, 2 and 3 are three of eight sites reported by the Navy in 1980 to have been used for disposal of wastes which may contain CERCLA hazardous substances. The Impoundment Area was used for the storage of industrial wastewater treatment sludge. Soils and wastes associated with Sites 1, 2 and 3 and the Impoundment Area, as well as Area A surface water and sediments, are being addressed under a separate operable unit (OU-9). Area A groundwater contains elevated levels of CERCLA hazardous substances and underlies part of NAWC property and off-base areas.

II. SITE HISTORY AND ENFORCEMENT ACTIVITIES

A. SITE HISTORY

NAWC is a 824-acre facility located in Warminster Township, Northampton Township, and Ivyland Borough, Bucks County, Pennsylvania (see Figure 1 for a site location map). As a result of the Base Realignment and Closure Act (BRAC), NAWC ceased operations on September 30,1996. The majority of NAWC, including Area A, is being transferred to the private sector.

The facility lies in a populated suburban area surrounded by private homes, various commercial and industrial activities, and a golf course. On-base areas include various buildings and other complexes connected by paved roads, the runway and ramp areas, mowed fields, and a small wooded area.

The Navy purchased the western portion of the base, including Area A, in July 1944. Before the Navy purchase, the property contained an aircraft manufacturing facility operated by the Brewster Aeronautical Corporation. Aircraft manufacturing and modification remained the primary mission at the base until 1949. After 1949, the overall mission of the base underwent a change from a manufacturing operation to a research

and development operation. Those activities varied over the years, but they included the development, research, and testing of aircraft components, coatings, electronics, and control devices. Concurrent with these activities, aircraft continued to be used and maintained.

NAWC also conducted studies in anti-submarine warfare systems and software development. Historically, wastes were generated during aircraft maintenance and repair, pest control, fire-fighting training, machine and plating shop operations, spray painting, and various materials research and testing activities in laboratories.

The generated wastes included paints, solvents, sludges from industrial wastewater treatment, and waste oils that were disposed in several pits, trenches, and landfills throughout the facility property. NAWC was listed on the Superfund National Priorities List (NPL) in 1989. This list comprises sites where uncontrolled hazardous substance releases present the most significant potential threats to human health and the environment. Areas reported by the Navy to have been potentially used for disposal of hazardous substances include eight locations covering more than 15 acres. These locations include the following:

- Three waste disposal locations (Sites 1, 3, and 6)
- Two sludge disposal pit locations (Sites 2 and 7)
- Two landfills (Sites 4 and 5)
- One fire training location (Site 8)

These disposal locations have since been grouped within the following areas on NAWC property**:** Area A (Sites 1, 2, and 3); Area B (Sites 5, 6, and 7); and Area C (Sites 4 and 8). A fourth general area, Area D, primarily includes the main building complex at the base and lies west of Jacksonville Road. Figure 2 provides the location of these areas.

In addition to Sites 1, 2, and 3, Area A includes the location of eight (8) former impoundments utilized for the storage of industrial wastewater treatment sludge, and adjacent areas in the northwest corner of the facility (Figure 3). Area A is bordered by an industrial area to the west and northwest and a wooded lot to the immediate north. Area A is a flat-lying area approximately 1,200 feet by 270 feet in size and covers approximately 7.4 acres. An unnamed tributary of Little Neshaminy Creek is located north of and drains surface runoff from Area A. The former NAWC Warminster wastewater treatment facility and NAWC parking lots are immediately to the south of Area A.

Site 1 is located near the northwestern corner of Area A. Site 1 was initially reported to be a burn pit used within an eroded ravine from approximately 1948 to 1950. Wastes reportedly disposed at Site 1 included inorganics, solvents, acids, bases and firing range wastes. An aerial photographic analysis conducted by EPA's Environmental Photographic Interpretation Center (EPIC) identified a pit (P1), a trench (TR 8), ground scar (GS

4) and disturbed ground (DG 2) to be present in the reported area of Site 1 in a period from the late 1940's to the early 1970's (see Figure 3). After use of Site 1 was discontinued, the area was reportedly covered with soil from an on-base source.

Site 2 was reported to be located immediately southeast of Site 1 and to have been used for the disposal of industrial wastewater treatment sludges from the surface impoundments. Site 2 reportedly consisted of two disposal trenches. An aerial photographic analysis conducted by EPIC identified a large surface dump (D1) and numerous other features suggesting potential disposal activities in the reported area of Site 2. Upon closure, Site 2 was reportedly covered with two feet of fill, regraded, and seeded.

Site 3 is immediately southeast of Site 2 and was reportedly used as a burn pit for solvents, paints, roofing materials, and other unspecified chemicals. No evidence of a pit or open burning was identified by an aerial photo analysis conducted by EPIC. However, disturbed ground and open storage (DG 1and OS 1) were noted in the area within the 1958-1973 time span. Upon closure, Site 3 was reportedly backfilled with on-base soil and regraded

NAWC formerly operated eight unlined lagoons for storage of industrial wastewater treatment plant sludge. The sludge likely contained residuals associated with plating operations formerly conducted at NAWC. These lagoons were located in the northern corner of Area A immediately south of Site 1 (Figure 3). The unlined lagoons were clean-closed in 1973, backfilled, and replaced with two concrete-lined surface impoundments.

A fuel farm was located immediately south of reported Site 2. This area included a gas station with gasoline and diesel fuel underground storage tanks (USTs), four 15,000 gallon USTs used for the storage of jet fuel, and an UST used for the storage of waste oil and possibly used solvents. All of the tanks have been removed by the Navy

B. ENFORCEMENT ACTIONS

No enforcement actions have been taken for Area A Groundwater. The Navy has owned the property since the mid-1900s and is the lead agency for CERCLA work at NAWC.

III. REMEDIAL INVESTIGATIONS AND RESPONSE ACTIONS

A detailed description of Remedial Investigation (RI) work addressing soils and wastes in Area A is included in the ROD issued for Area A soils and wastes in June 2000. The discussion below focuses on investigations of Area A groundwater. The CERCLA RI process addressing NAWC and Area A groundwater has been conducted in phases.

The Phase I RI addressing Area A groundwater was conducted from 1989 through 1991. Phase I RI activities included the installation of overburden and shallow bedrock monitoring wells, groundwater sampling and analysis, an off-base well inventory and a fracture-trace analysis (SMC Martin, 1991).

The Phase II RI and feasibility study (FS) were conducted from 1992 through 1993. Additional RI work was performed to further determine the nature and extent of on-base groundwater contamination, evaluate shallow groundwater flow, and add to the hydrogeologic database. Activities included installing additional overburden and shallow bedrock monitoring wells, sampling and analyzing groundwater, evaluating aquifer characteristics through water-level monitoring and a pumping test, and an assessment of risks posed by Area A groundwater. In response to the findings of this RI work, an FS was performed to identify and evaluate potential remedial alternatives for contaminated Area A groundwater in overburden and shallow bedrock aquifers. Interim RI and FS reports for Area A groundwater were released in April 1993 (HNUS, 1993a and 1993b). These interim reports described the nature and extent of contamination and remedial alternatives based on data available at the time

Based on these reports, the Navy and EPA selected an interim remedy for contaminated groundwater attributable to Area A in overburden and shallow bedrock aquifers in an interim remedy ROD for Operable Unit 1 (OU-1) dated September 1993 (this ROD also selected an interim remedy for Area B groundwater). The primary contaminants of concern were chlorinated volatile organic compounds (VOCs). The ROD selected an interim remedial action to minimize the migration of contaminated groundwater while additional RI work was performed to determine the full nature and extent of Area A groundwater contamination. The interim remedy included pumping and treatment of Area A groundwater and periodic testing of groundwater in monitoring wells and other wells near the base. While the groundwater treatment system was constructed by July 1996, the drilling and installation of Area A extraction wells was deferred while additional RI work addressing Area A soils and groundwater was completed.

From 1993 through 1995, the Navy expanded Area A groundwater studies to address deep aquifers and off-base, downgradient areas. Determination of both the lateral and vertical extent of groundwater contamination and hydrogeologic conditions within Area A were the focus of these investigations. Previous and new monitoring wells were sampled and a water-level study was performed (HNUS, 1995). The results of these investigations indicated that Area A groundwater of concern had migrated to off-base areas. In addition, the detection of high concentrations of contaminants on-base suggested the potential presence of Dense Non-Aqueous Phase Liquid (DNAPL) contamination in the bedrock aquifer. In conjunction with these investigation

results, the Navy upgraded the air stripper on a downgradient municipal water supply well [Warminster Township Municipal Authority Well No. 26 (WTMA 26)] to ensure that the water supply was protected and connected a nearby commercial facility, dependent on a private well, to a public water supply system.

In 1996 and 1997 the Navy conducted additional investigations to better characterize groundwater flow and hydrogeologic conditions in and around Area A. An inactive, off-base commercial production well was tested in December 1996 to evaluate the hydrogeologic conditions within the well, investigate the hydraulic connection between the well and Area A groundwater, and evaluate groundwater quality conditions at different depths within the well. The project included packer testing and sampling activities for the deep open borehole well and hydrogeologic monitoring of nearby monitoring wells. This investigation was specific to the inactive production well and did not include the sampling analysis of Area A groundwater. Descriptions of the results of this investigation are contained in USGS Water Resources Investigations Report 97-4095 (Sloto, 1997) and a letter report submitted to the Navy in February 1997 (Brown and Root Environmental, 1997).

In September of 1997, the Navy performed a water level study of Area A groundwater which addressed off-base/downgradient areas. The study, which did not include the collection of groundwater samples, was performed to determine the impacts of the operation of WTMA 26 on groundwater levels and flow direction in the area between the well and the base. A total of 40 wells were monitored during the study. Details of the results of this investigation are provided in an August 1998 letter report (Brown and Root Environmental, 1998).

In 1997, the Navy also conducted a comprehensive round of groundwater monitoring that included all available monitoring wells in and downgradient of Area A. The comprehensive round of groundwater monitoring was performed to provide an updated "snapshot" of groundwater conditions and included the collection of comprehensive rounds of water level measurements. The Summary Report for Areas A and D Groundwater Monitoring (Brown and Root Environmental, 1998) provides the results of this round of monitoring, including groundwater flow maps, contaminant distribution maps, and the complete analytical database.

As noted, additional monitoring wells were installed during the period from 1995 through 1998 to support the final RI for Area A groundwater. Eight well clusters were installed off-base north and west of Area A, while one well cluster was installed on-base near the northwest corner of Area A. Three additional well clusters were installed south and east of Area A, to provide upgradient monitoring points.

In addition, since 1994, the Navy has been conducting a base perimeter monitoring program. This program, consisting of the sampling of selected wells on base and in the surrounding areas (including within and around Area A), has been performed on a periodic basis by the Navy as a part of the monitoring required by RODs issued by the Navy and EPA. Following each round of perimeter monitoring a report has been generated, providing the results along with historic data from previous rounds of monitoring. From 1994 to present, 14

rounds of perimeter monitoring have been performed, with the most recent round completed in June 2000.

As indicated above, the installation of groundwater extraction wells addressing Area A groundwater was deferred while Area A soil removal actions and necessary groundwater investigations were complete. Following soil excavation/removal activities performed within Area A in 1998, a total of 18 potential extraction and/or performance monitoring wells were drilled on-base within Area A from January through March 1999. Of the 18 wells, 14 were subsequently completed as groundwater extraction wells and 4 as monitoring wells. The extraction system drilling/testing/construction program included well drilling, open borehole yield tests with associated sampling, construction of 6-inch diameter stainless steel extraction wells in the boreholes selected to be extraction wells, and the hookup of the extraction wells to the groundwater treatment plant constructed in the western portion of Area A. Monitoring of nearby wells was performed throughout the extraction well installation program, as well as DNAPL screening for the wells being drilled and selected nearby wells. Data generated by these activities provided further indication of the potential presence of DNAPL contaminants in the bedrock aquifer. The extraction wells became operational on a full time basis in July of 1999. Details regarding the drilling, testing, monitoring, and installation of the extraction wells are provided in the report "Installation/Testing of Area A Groundwater Extraction Wells at Naval Air Warfare Center Warminster, Pennsylvania" (Foster Wheeler, 1999).

A second phase of Area A extraction/observation well drilling was performed from December 1999 through January 2000. A total of 6 wells were drilled on the property immediately north of Area A, using drilling/monitoring/testing procedures similar to those used for the onsite Area A extraction wells. Based on the results of field testing and data from the operation of the onsite Area A extraction system, one of the 6 wells was converted and completed as a potential extraction well. The remaining five wells were completed as monitoring wells. Details regarding this second phase of activity are provided in the report "Summary of Off-Site Drilling/Testing North of Area A" (Foster Wheeler, 2000).

As part of the interim remedy, the Navy has been implementing a performance monitoring program to monitor the effectiveness and operation of the interim remedy extraction system. Performance monitoring activities for the Area A extraction system have been underway since June 1999, immediately prior to the startup of the on-base extraction system. The performance monitoring has included the collection and analysis of groundwater samples from the extraction wells and selected nearby monitoring wells, the collection/mapping of periodic rounds of water levels and the evaluation of the resultant data. Three performance monitoring reports have been generated to date: the Pre-Startup and Startup Performance Monitoring Report for Remedial Action at Operable Unit 1 and Operable Unit 4 (EA Engineering, 1999), the June through December 1999 Performance Monitoring Report for Remedial Action at Operable Units 1A and 4 (EA Engineering, 2000) and the December 1999 through February 2000 Performance Monitoring Report for Remedial Action at Operable Units 1A and 4 (EA Engineering, 2000).

In addition to the performance monitoring program, the Navy conducted a focused groundwater sampling event in May 2000 to determine whether groundwater had been impacted by releases of metals from Area A. Based on a review of historical sampling data, a total of 18 wells were sampled. This effort and the results are discussed in the final RI/FS report for Area A Groundwater issued by the Navy in June 2000 (TtNUS, 2000). The final RI/FS report for Area A Groundwater (TtNUS, 2000) also contained the results of the other RI work performed since the issuance of the interim RI/FS as well as available performance monitoring information for the operating interim pump and treat remedy.

IV. HIGHLIGHTS OF COMMUNITY PARTICIPATION

In accordance with Sections 113 and 117 of CERCLA, the Navy provided a public comment period from July 10, 2000 to August 9, 2000 for the proposed final remedial action described in the final FS and the Proposed Plan for OU-1A. These documents were available to the public in the Administrative Record and information repositories maintained at the Navy Caretaker Site Office located at 860 Flamingo Alley, Warminster, Pennsylvania and at the Bucks County Library located at 150 South Pine Street, Doylestown, Pennsylvania. Public notice was provided in the *Bucks County Courier Times, Philadelphia Inquirer*, and *Intelligencer* and a public meeting was held on July 19, 2000 at the North American Technology Center located at 626 Jacksonville Road in Warminster, Pennsylvania. Comments received during the public comment period are presented in Appendix C. Additional community involvement, including Restoration Advisory Board (RAB) activities, are detailed in Section XIV.

V. SCOPE AND ROLE OF RESPONSE ACTION

Section 300.430 (a) (1) (ii) (A) of the NCP, 40 C.F.R. Section 300.340 (a) (1) (ii) (A) provides that CERCLA NPL sites "should generally be remediated in operable units when early actions are necessary or appropriate to achieve significant risk reduction quickly, when phase analysis or response is necessary or appropriate given the size or complexity of the site, or to expedite the completion of a total cleanup." In the case of NAWC Warminster, the Navy has organized work to date into ten operable units (OUs). These OUs are as follows:

- OU-1: Area A and Area B groundwaters.
- OU-2: Off-base private wells.
- OU-3: Area C groundwater.
- OU-4: Area D groundwater.
- OU-5: Soil, sediment and surface water at Site 8.
- OU-6: Soil, sediment and surface water at Site 4.

- OU-7: Soil and waste at Sites 6 and 7.
- OU-8: Soils in Area D
- OU-9: Soil, sediment, and surface water at Area A.
- OU-10: Soil at Site 5 and surface water and sediment at Area B.

The Navy and EPA selected an interim remedy for OU-1 in a ROD issued on September 23, 1993 and the removal action for OU-2 was selected by EPA in a Removal Action Memorandum signed on July 14,1993. The Navy and EPA selected a final remedy for OU-3 in a ROD signed March 10, 1995. In September 1999, the Navy and EPA determined that institutional controls were necessary to prevent the use of Area C groundwater presenting an unacceptable human health risk and to protect the long-term effectiveness of the OU-3 remedy. An Explanation of Significant Differences (ESD) was signed to make changes to the OU-3 ROD. The institutional controls address portions of Area C (including Sites 4 and 8) on both current Navy and private property, and consist of restrictions on the use of water from existing wells, restrictions on the future installation of wells, and restrictions on the use wells installed in the future.

An interim remedy for OU-4 was selected in a ROD signed by the Navy and EPA on September 30,1997 and a final ROD for OU-4 was signed in June 2000. A no further action ROD for OU-5 was signed by the Navy and EPA on September 30, 1999, while a no further action ROD for OU-6 was signed in June 2000. Final remedies for OU-7, OU-8, and OU-9 have also been selected and final RODs for these OU's were signed in June 2000. The final remedies for OU-7 and OU-9 are in the construction phase and a no action remedy was selected for OU-8. The selected interim remedy for Area A groundwater portion of OU-1 (OU-1A), the final remedy for OU-4, and the final remedy for OU-3 are all operational at this time and the removal action addressing OU-2 has been completed. A Proposed Remedial Action Plan for OU-10 was issued for public comment on August 7, 2000.

The interim remedy for OU-1 selected pumping and treating of Area B groundwater to minimize migration while additional investigations were completed. Data generated during the construction of the interim remedy extraction wells in Area B did not detect contamination in excess of cleanup goals. In response, the pumping and treating of Area B groundwater was deferred. Additional investigations of Area B groundwater have since been completed and a final remedy of no action has been selected for Area B Groundwater (OU-1B).

This ROD documents the selected final remedy for OU-1A, Area A Groundwater.

VI. SITE CHARACTERISTICS

NAWC is situated on an upland area divided between two local drainage basins, the Little Neshaminy Creek Basin on the north and the Pennypack Creek Basin on the south. The northern 65 percent of the facility

(including Area A) drains toward the north through several swales and storm sewers into small unnamed tributaries of Little Neshaminy Creek. A small tributary, which drains Area A, begins near Jacksonville Road on the northwestern side of the base. Between the base boundary and Bristol Road, this tributary flows through developed areas with numerous small manufacturing plants, apartment complexes, restaurants, and single-family residences, to Little Neshaminy Creek, approximately 2.5 miles from NAWC Warminster.

Area A soils are classified as urban land. Urban land occurs in highly developed areas where urban structures and works cover so much of the land type that identification of the soils is not practical. Most areas have been graded, and the original soil material has been disturbed, filled over, or otherwise altered prior to construction. Soils observed within NAWC during current and previous RI field work ranged from 2 feet to more than 15 feet in thickness. Soil types observed included orange-red, brown and maroon-red mixtures of silt, clay, and sand, with the finer-grained soils dominant.

The geology of Area A consists of alternating coarse and fine grained sedimentary bedrock units of the Stockton Formation underlying a thin veneer of clayey residual soils. The soils consist primarily of silt and clay, with minor amounts of sand and rock fragments. Typically, the soils grade into weathered bedrock at depths of about 8-10 feet below ground surface, and to competent bedrock at a depth of about 15 feet. The transition from soils to weathered bedrock to competent bedrock occurs gradually and varies somewhat in depth across Area A.

The bedrock units of the Stockton Formation dip gently to the north-northwest. Lithologic units vary in thickness from less than a foot to about 50 feet typically. The fine grained lithologic units are described as mudstones and typically consist primarily of red-brown siltstones and shales. The coarser grained rock units typically consist of fine to coarse grained arkosic sandstones, ranging in color from red-brown to gray and green-gray. RI investigations found that transitions from one lithologic type to another ranged from well-defined, gradational sequences to fairly abrupt lithologic transitions. In general, the gradational sequences tended to be fining-upward, sandstone to mudstone transitions while the sharper, more abrupt transitions tended to be from lower mudstone units to overlying sandstones. This pattern of sediment deposition is typical of alluvial systems. Exceptions to these generalized transition types were not uncommon, however; gradational mudstone to sandstone contacts and abrupt sandstone to mudstone contacts were also evident in the geophysical logs of the monitoring well borings.

Based on boring log data from monitoring wells in the vicinity of Area A, a continuous mudstone unit underlies Area A and nearby downgradient areas. Bedrock units generally strike north 72^{o} east and dip 6.4^{o} to the northwest. The strike and dip of the bedrock units across the study area is generally consistent with the observed strikes and dips of the bedrock units within Areas B (N71^{o}E, 5-8^{o} NW) and C (N 70^{o}E, 9^{o} NW) at NAWC. The dip direction of the bedrock units generally follows topography in this area, thus the bedrock units that outcrop or occur at shallow depths within the vicinity of Area A are encountered at greater depths

in areas farther to the north-northwest.

Logs from wells installed within and adjacent to Area A indicate that major lithologic units tend to be laterally persistent across and downgradient of Area A. The coarse-grained sandstone units may in some cases consist of laterally and vertically extensive packages of coalescing sandstone beds as opposed to singular, discrete lithologic units. Fractures were encountered at varying depths in the well borings drilled within and downgradient of Area A. The fractures were encountered both at lithologic contacts (bedding plane fractures) and within lithologic units (cross bedding fractures). Both sandstones and mudstones were observed to be fractured to varying degrees.

The major source of groundwater in the vicinity of NAWC is the fractured bedrock of the Stockton Formation. The middle arkose member of the Stockton Formation is considered to be the most productive bedrock aquifer in Bucks County. These rocks form a multi-aquifer system of relatively discrete water-bearing zones separated by less permeable zones. Transmissivity and groundwater movement within water-bearing zones are greater parallel to bedding than across bedding. Groundwater in the Stockton Formation occurs locally under both confined and unconfined conditions.

Within water-bearing zones in the fine- and medium-grained sandstone of the Stockton Formation, groundwater is transmitted chiefly through fractures, joints, and bedding planes (secondary permeability and porosity). Primary porosity is minimal in these rock units. The shale and siltstone beds are commonly too fine-grained to transmit large amounts of groundwater through primary permeability. Vertical or nearly vertical fractures cutting across bedding and the weathering of various beds are expected to permit varying degrees of leakage between individual water-bearing zones, particularly near the surface. Fractures are typically not well developed in the fine-grained beds. Consequently, the shale and siltstone beds often act as confining layers to groundwater. Secondary (fracture) permeability is generally better developed in the sandstone layers compared to the shale and siltstone layers of the formation. This, along with greater primary permeability (although still minor), allows the sandstone layers to function as the most productive water-bearing units of the Stockton Formation in general.

Groundwater in the vicinity of Area A occurs primarily within the underlying bedrock units. Groundwater is encountered in discrete fractures within the rock mass. Interconnected networks of fractures within the bedrock serve as the primary groundwater migration pathways. Some minor primary (intergranular) permeability may exist within the bedrock, however it is insignificant in comparison to the secondary (fracture) permeability. The soils overlying bedrock contain minor amounts of water in places on a seasonal basis, primarily along the northern edge of Area A near the base boundary.

Within the bedrock, the sandstone units function as the primary water-transmitting units, while the fine-grained mudstone units act as semiconfining layers to groundwater flow. Both sandstones and mudstones are

fractured to varying degrees; however, fractures in the sandstones tend to have higher yields and as a result the sandstone units act as preferential zones of groundwater flow. Below a depth of about 80-100 feet, groundwater occurs under semiconfined conditions. Within the study areas, significantly higher hydraulic heads are typically observed in deep (>200 feet) portions of the bedrock in comparison to hydraulic heads in the shallower bedrock.

The interpretations of the study area hydrogeology presented below have been focused primarily on three hydrogeologic units, designated as hydrogeologic units A, B, and C. Each hydrogeologic unit consists of one of more laterally extensive sandstone beds and adjacent mudstone units, which, based on hydrogeologic and water quality data, form an interconnected, discrete groundwater flow system.

Hydrogeologic unit B is the hydrogeologic unit of most importance to the investigation in terms of groundwater contaminant occurrence and migration from Area A. This hydrogeologic unit is comprised of the sandstone unit found at shallow depths throughout Area A, and generally found at depths of 15 to 100 feet along the northern edge of Area A. Within Area A and in the near-downgradient area, the sandstone bed is locally split by a thin mudstone unit that pinches out further to the north and east. To the north-northwest of Area A, hydrogeologic unit B is found at increasing depths, following the overall dip of the geologic units. Hydrogeologic unit B is the hydrogeologic unit with the highest levels of groundwater contaminants attributable to releases within Area A (see Section VII). The OU-1 interim remedy extraction wells are installed into this unit. Based on geophysical log correlations, hydrogeologic unit B is encountered in the lower portion of municipal well WTMA 26, which is located approximately 1900 feet north-northwest of Area A.

Hydrogeologic unit A includes several mudstone and sandstone units that overlie hydrogeologic unit B. The two hydrogeologic units are separated by a continuous mudstone both on and offsite. Hydrogeologic unit A is encountered at the bedrock surface along the northern edge of Area A and at increasing depths to the north-northwest across the downgradient portion of the study area. Because hydrogeologic unit A outcrops along the northern edge of Area A, it is absent across most of Area A. Based on geophysical log correlations, hydrogeologic unit A is encountered in the upper portion of WTMA 26.

Hydrogeologic unit C underlies hydrogeologic unit B within and downgradient of Area A. Hydrogeologic unit C wells are primarily completed in a thick (40 ft +) sandstone unit encountered approximately 30 feet below the hydrogeologic unit B sandstone bed, but also includes wells installed into deeper strata. As with the other hydrogeologic units, water level data and contaminant data were also considered along with lithologic data in grouping wells into hydrogeologic unit C. Based on geophysical log correlations, WTMA 26 does not intersect hydrogeologic unit C.

The overall groundwater flow direction across the study area within hydrogeologic unit A is generally to the

north and northwest (see Figure 4). Within the outcrop area for hydrogeologic unit A, the groundwater flow direction is to the north following ground surface topography. Further downgradient and down-dip, as the depth of hydrogeologic unit A increases, the flow direction changes to the north-northwest. This pattern of flow is interpreted to indicate that shallow, weathering-related fractures control groundwater flow in outcrop areas (which results in local flow following topography), while a combination of bedrock structure and the pumping of WTMA 26 plays a greater role in influencing groundwater flow patterns at depth. There is also a slight northeastward component of groundwater flow in the northwestern portion of the study area, which is likely a reflection of WTMA 26 pumping-related effects. Measured groundwater flow gradients range from 0.026 (in the eastern portion of the study area) to approximately 0.08 (in the northwest portion of the study area).

Groundwater flow within hydrogeologic unit B is also generally to the north and north-northwest following ground surface slope and bedrock dip, as shown in Figure 5. As was observed for hydrogeologic unit A, the groundwater flow direction within the outcrop area for hydrogeologic unit B is to the north following ground surface topography. Further downgradient and down-dip, as the depth of hydrogeologic unit B increases, the flow direction changes to the north-northwest. This pattern of flow is interpreted to indicate that shallow, weathering-related fractures control groundwater flow in outcrop areas (which results in local flow following topography), while a combination of bedrock structure and the pumping of WTMA 26 plays a greater role in influencing groundwater flow patterns at depth. As with hydrogeologic unit A, there is also a slight northeastward component of groundwater flow in the northwestern portion of the study area which is likely a reflection of WTMA 26 pumping-related effects. The lateral groundwater flow gradient for the hydrogeologic unit B flow system ranges from 0.027 to 0.065. The flow gradient is lowest within Area A and steepens in the north-northwestern portion of the study area.

Within hydrogeologic unit C, groundwater flow is to the north across Area A and downgradient as shown in Figure 6. The flow gradient in this deeper flow system averages about 0.026. WTMA 26 pumping-related effects are not seen in hydrogeologic unit C, which is stratigraphically below the strata from which WTMA 26 draws water. As expected based on the large vertical head differentials seen among wells at many well cluster locations (see discussion of vertical groundwater flow below), the intervening mudstone units limit the vertical hydraulic connection between this deep flow zone and overlying flow zones.

The local surface water body within the area (a small tributary to Little Neshaminy Creek) has a streambed elevation between 250 to 300 feet mean sea level (msl) within the study area. Groundwater elevations in hydrogeologic unit A monitoring wells as low as 220.59 feet msl (HN52S) and 218.11 ft msl (HN-65I1), which are well below the streambed elevations, were measured during the December 1997 round of water level measurements. Groundwater elevations in hydrogeologic unit B wells as low as 237.05 feet msl (HN52I) and 239.53 ft msl (HN-65I2), which are also below the streambed elevations, were measured during the December

1997 round of water level measurements. The increases in flow gradient to the north-northwest observed for both hydrogeologic units A and B suggest a nearby groundwater discharge point, and the groundwater levels at elevations below the nearby surface water bodies indicate a subsurface discharge point (i.e., a well) for the groundwater. WTMA 26 is located in the general downgradient direction and is the closest known pumping well. Well clusters HN-65 and HN-52 are the farthest downgradient well clusters and are most closely aligned along strike with WTMA 26. Based on the reported water level in WTMA 26 while operating (approximately 130-160 feet below ground surface, which, in combination with an estimated ground surface elevation of approximately 260 feet msl, results in a pumping level of about 130-100 feet msl), flow from throughout the study area to the municipal well is likely occurring in hydrogeologic units A and B.

Based on water level data and lithologic interpretations, changes in hydraulic head due to the operation/shutdown of WTMA 26 vary considerably with depth. At well cluster HN-65, water level recoveries due to the two-day shutdown of the municipal well during the Area A/offsite water level study varied by approximately 12 feet, with the greatest effects seen in hydrogeologic unit A and B wells (12.01 and 9.21 feet, respectively) and little or no effects seen in the shallowest (0.0 feet) and deepest wells (0.11 feet) within the cluster. At cluster HN-52, water level recoveries ranged from 0.16 feet to 9.74 feet, with the hydrogeologic unit A and B wells responding the most (9.74 and 9.60 feet, respectively) and the deep well the least. As stated previously, these wells are the most closely aligned along strike with WTMA 26.

Water level recovery effects on-base and immediately downgradient of the Area A due to the shutdown of WTMA 26 were minor in comparison. Water level recoveries due to the shutdown of the well are approximately equal to the drawdowns that would be seen over the same time period of pumping and illustrate the depth-dependent and location-dependent (especially alignment-related) nature of the magnitude of impacts of the operation of WTMA 26 on study area groundwater levels, and also the vertical restriction of flow due to the layered geology of the site.

Vertical groundwater flow gradients are generally upward from the deeper flow zones to shallower flow zones in the Area A groundwater monitoring wells. In all cases where deep wells were installed at a cluster location (except at well cluster HN-22S/I/D), the deepest wells had the highest water levels within a given well cluster, and in some cases, the deep wells are flowing artesian wells. The maximum head differentials were observed in the well clusters located downgradient of Area A.

The large head differentials observed within well clusters located downgradient of Area A are believed to be related to two factors. The outcrop areas for the strata monitored by the deep wells within the study area are in topographically higher areas near the runway to the south of Area A. Precipitation recharge and the high water table within these outcrop areas are responsible for the high hydraulic heads measured in the deeper wells. Hydrogeologic units A and B receive recharge from closer, topographically lower areas of the base,

and the water table in Area A is substantially lower than the water table in the runway area, thus the head differentials observed are partly a reflection of the different recharge areas.

In addition, the shallower groundwater in the vicinity of Area A is more hydraulically connected to local groundwater discharge points. As described above, the pumping of WTMA 26 in particular preferentially draws water from discrete depth intervals within the study area, including hydrogeologic units A and B, decreasing the hydraulic heads within these water yielding zones.

The overall pattern of vertical head differentials indicates that groundwater in the bedrock exists under semiconfined to confined conditions. The large hydraulic head differentials seen between wells at cluster locations indicates that laterally persistent mudstone units act as significant barriers to vertical groundwater flow and that groundwater flow parallel to bedding occurs much more readily than cross-formational flow. Also, the presence of highest hydraulic heads in the deeper bedrock flow zones indicates that vertical movement between the deep groundwater and overlying flow zones is upward.

The OU-1 interim remedy groundwater extraction system has been in operation since mid-1999, with 12 wells (EW-A1, A2, A3, A4, A6, A7, A8, A10, A11, A12, A13, and A15) pumping at an average cumulative discharge rate of 40 gpm. All of the extraction wells are completed in and draw water from hydrogeologic unit B. Two other extraction wells (EW-A5 and EW-A9) are currently inactive but are configured for pumping at a later date.

Within the area of highest TCE concentrations, the presence of DNAPL has been inferred through the detections of TCE in groundwater at concentrations of greater than 100 mg/L (the solubility of TCE is approximately 1,100 mg/L) and has been confirmed through dye testing (see Nature and Extent of Contamination, Section VII). Selective pumping of the extraction wells containing DNAPL and the highest TCE concentrations (EWA6 and EWA7) is currently being performed. Adjacent extraction wells EWA5 and EWA9 are not being pumped to avoid pulling DNAPL from the immediate vicinities of these two wells. Once the TCE levels in EWA6 and EWA7 drop to the point where the concentrations are similar to those in the surrounding wells, it is anticipated that extraction wells EWA5 and EWA9 will be activated. In addition, a nearby offsite extraction well (HN-71) is currently under construction and will be added to the extraction system in the near future.

The hydraulic effects of the interim remedy groundwater extraction system have been evaluated based on water level data gathered during pre-startup through month three performance monitoring activities. Pre-startup groundwater flow patterns in the vicinity of the extraction system were established using "Day -7" (June 21, 1999) water level data. As shown on Figure 7, the hydrogeologic unit B groundwater flow direction

across the on-base and near-off-base portion of the study area is to the north-northwest. In the vicinity of the extraction wells, the groundwater flow gradient averages approximately 0.02, and steepens in the area west of the railroad tracks.

Groundwater flow patterns in the same area under extraction system operating conditions were evaluated using "Month 3" (November 15, 1999) data. Based on these data, drawdowns due to pumping are evident within hydrogeologic unit B in the general area and especially in the immediate vicinity of the onsite extraction wells, as shown on Figure 8. Figure 9 shows an expanded view of the same groundwater flow field. The extraction system aggregate pumping rate for the month prior to the Month 3 round of water levels averaged 39 gpm, and the potentiometric surface shown on Figures 8 and 9 generally reflects this total flow rate.

The water level contours and flow arrows drawn for the Month 3 set of water level data (see Figure 9) suggest that the capture zone of the extraction system extends within hydrogeologic unit B across the area of the extraction well network and onto a portion of the adjacent property formerly owned by John C. Wagner and Sons (now owned by the Navy). Groundwater west of the rail line which runs along the NAWC property does not appear to be captured by the extraction system constructed as part of the interim remedy (except in the immediate vicinity of the extraction system) and is migrating in a north-northwest direction, similar to the flow direction under non-pumping conditions.

The interim remedy extraction system was designed to contain groundwater within the source area for contaminants that have been identified within Area A, to stop the migration of contaminants from the source area. The performance data gathered to date indicate that the system is containing the source area contamination.

VII. OCCURRENCE AND DISTRIBUTION OF CONTAMINANTS

This section summarizes data regarding the occurrence and distribution of contaminants detected by RI work addressing Area A groundwater. The results of major RI sampling results are presented and discussed separately.

A. Interim RI

The occurrence and distribution of organics, unfiltered (total) inorganics and filtered (dissolved) inorganics in monitoring wells installed and sampled as part of the interim RI for Area A groundwater appear in Tables 2, 3 and 4 of the Interim Remedy ROD and are presented in Appendix B. The location of the monitoring wells installed and sampled as part of the interim RI is provided in Figure 4 of the Interim Remedy ROD and is also presented in this same attachment. At the time, 24 monitoring wells were in place and sampled. All monitoring wells at that time were located on-base. In order of decreasing frequency, the six most frequently detected

organic contaminants were trichloroethene (TCE), 1,1-dichloroethane (1,1-DCA), 1,2-dichloroethene (1,2-DCE), cis-1,2-dichloroethene (cis-1,2-DCE), 1,1-dichloroethene (1,1-DCE), and tetrachloroethene (PCE). TCE, cis-1,2-DCE and PCE were the organics with both the highest representative and maximum concentrations. The Interim Remedy ROD found that TCE, PCE, cis-1,2-DCE, carbon tetrachloride (CCl_4), vinyl chloride, 1,1-DCE, 1,2-DCA, and chloroform in contaminated groundwater attributable to Area A contributed to an unacceptable human health risk. The Interim Remedy ROD also found that average concentrations of TCE and PCE exceeded MCLs and that MCLs had been exceeded for CCl_4 vinyl chloride and 1,2-DCE in individual groundwater samples collected within Area A. With regard to inorganics, the Interim Remedy ROD found that arsenic, manganese, thallium, and barium in Area A groundwater contributed to an unacceptable health risk and found that MCLs (or SMCLs) had been exceeded for cadmium, manganese, nickel, arsenic and barium in individual well samples collected within Area A.

B. Post-interim RI

As part of the work performed since the interim RI, numerous additional monitoring wells have been installed to determine the nature and extent of contaminated groundwater attributable to releases within Area A. A primary objective of the additional monitoring wells was to determine the extent of contaminated Area A groundwater downgradient of Area A and vertical extent of contaminated Area A groundwater. Many of the additional monitoring wells were installed off-base within an area of industrial land use downgradient of Area A. The location of monitoring wells in place. at this time and sampled since the interim RI is provided in Figure 5. This figure also provides the location of the extraction wells installed as part of the interim remedy.

The balance of this section summarizes the results of sampling and analysis of groundwater from monitoring and extraction wells installed as part of the interim remedy for Area A groundwater. Only the results of the most comprehensive groundwater sampling and interim remedy performance monitoring events are presented. The other sampling events that lead up to the comprehensive monitoring programs (including the focused efforts discussed in Section III) provided data that were used to help direct further investigations and to install additional monitoring and extraction wells that were sampled as part of the comprehensive groundwater sampling and performance monitoring programs. The results of these groundwater investigations were consistent with those presented below and did not significantly impact the contaminant trends noted for Area A groundwater. Similarly, the results for the perimeter monitoring program are not presented below. This program includes the periodic collection and analysis of groundwater samples from within Area A, and the results of this program are consistent with the findings summarized and presented below.

- Comprehensive Area A Groundwater Sampling 1997

Upon installation of the majority of the monitoring wells indicated on Figure 5, a comprehensive sampling

event was performed from December 1997 through January 1998 and included all accessible groundwater monitoring points within Area A and in off-base areas located downgradient of Area A. The sample locations included on-base monitoring and production wells and off-base monitoring and drinking water wells, including WTMA Well 26 (see Summary Report for Areas A and D Groundwater Monitoring, Brown & Root Environmental, 1998). All samples were analyzed for EPA Target Compound List (TCL) volatile organic compounds (VOCs). In addition, eight wells were sampled and analyzed for EPA Target Analyte List (TAL) inorganics; and cyanide. All of the analytical results were validated per the Quality Assurance Project Plan for RI work at the site.

Tables 1, 2 and 3 present information regarding the occurrence and distribution of organics and inorganics in monitoring wells installed to monitor hydrogeologic units A, B and C (hereafter referred to as units A, B and C), respectively. Figures 10,11 and 12 provide selected sample results. The six most frequently detected organics in all units were, in order of decreasing frequency, TCE, PCE, 1,1-DCE, cis-1,2-DCE, 1,1-DCA, and 1,1,1-trichloroethane (1,1,1-TCA). A comparison to the organics detected most frequently during the interim RI indicates a relative increase in the frequency of detection of PCE, 1, 1-DCE and 1, 1, 1 -TCA in the final RI monitoring well network. The organics with the highest maximum concentrations, in order of decreasing concentration, were TCE,CCl_4, and PCE.

TCE was detected at a maximum concentration of 32,000 ug/l (in a new on-base well), as compared to a maximum of 2,100 ug/l during the interim Rl. CCl_4 was detected at a maximum of 990 ug/l, as compared to 44 ug/l during the interim RI. The maximum PCE concentration (420 ug/l) was similar to the maximum concentration detected during the interim RI (440 ug/l). While the maximum level of cis-1,2-DCE reported during the interim RI was 510 ug/l, the maximum detected during this sampling event was only 72 ug/l.

As shown on Table 3 and in Figure 12, detected organic contaminant levels in hydrogeologic unit C wells were in all cases below 5 ug/l. TCE was detected in 4 out of 6 samples and at a maximum concentration of 4 ug/l. No other organic contaminant was detected more than once out of the 6 samples collected from unit C wells.

The highest concentrations of TCE were found in hydrogeologic unit B wells HN-11l (32,000 ug/l), HN-59I (12,000 pg/L), HN-55I (7,800 Fg/L), HN-16I (2,300 Fg/L), and HN-14I (2,300 Fg/L). These wells are within about 800 feet of one another and are within or immediately downgradient of Area A. TCE concentrations generally decreased in the downgradient direction. Significant but substantially lower levels of TCE were identified in the shallower hydrogeologic unit A. The maximum level of TCE in hydrogeologic unit A (360 ug/l) was detected in well HN-50S, about 1,400 feet north-northwest of Area A. Two other areas of elevated TCE concentrations were noted in unit A. The first area is immediately north of Area A and includes wells HN-59S, -14S, and -15S, with TCE levels of 160, 290, and 150 Fg/L, respectively. The second area is in the vicinity of well HN-52S, where TCE was detected at a concentration of 140 Fg/L.

The maximum level of PCE (420 ug/l) was detected in off-base hydrogeologic unit A well HN-52S, located approximately 900 feet northwest of the northwest corner of Area A. The next highest PCE detections (up to 160 ug/l) were detected onbase in hydrogeologic unit B within the area bounded by HN-55I, HN-12S, E, D, and SMC-01. PCE concentrations in excess of the MCL of 5 Fg/L within hydrogeologic unit B extend off base to the northwest.

CCl_4 was detected most frequently and at the highest levels within on-base hydrogeologic unit B wells. The maximum concentration detected was 990 Fg/L (HN-11I). Generally, CCl_4 was only found in samples with high TCE concentrations. The highest levels Of CCl_4 detected in hydrogeologic unit A was in on-base well SMC-01 (12 Fg/l). No off-base wells contained CCl_4 at concentrations higher than those detected in on-base wells.

The maximum concentration of 1,1-DCE (210 ug/l) was detected within hydrogeologic unit A in off-base well HN-52S. The highest levels of 1,1-DCE within unit B (22 ug/l) was detected in WTMA 26. The only other level detected in unit B wells in excess of the MCL (7 ug/l) was detected in on-base well HN-11I.

The maximum concentration of cis-1,2-DCE (72 ug/l) was detected in hydrogeologic unit B in on-base well HN-12S. This was the only location where cis-1,2-DCE exceeded the MCL for cis-1,2-DCE (70 ug/l).

The maximum levels of both 1,1-DCA and 1,1,1-TCA were detected in off-base hydrogeologic unit A well HN-52S, where 1,1-DCA was detected at 190 ug/l and 1,1,1-TCA was detected at 340 ug/l. The MCL for 1,1,1-TCA is 200 ug/l, while there is no MCL for 1,1-DCA. The maximum on-base concentrations of 1,1-DCA and 1,1,1-TCA were 2 ug/l and 1 ug/l, respectively and both compounds were detected in only hydrogeologic: unit B wells.

Two other organics were detected at concentrations exceeding MCLs during this sampling event. 1,1,2-trichloroethane (1,1,2-TCA), which has an MCL of 5 ug/l, was detected at a maximum concentration of 67 ug/l in on-base hydrogeologic unit B well HN-11I. The maximum levels of benzene (10 ug/l) also was detected in this well and exceeded the MCL of 5 ug/l.

Eight monitoring wells were sampled for inorganics (see Tables 1, 2 and 3 for results). Based on a comparison to background concentrations and MCLs, only iron was identified as a potential contaminant of concern.

- Pre-Startup, Startup and Performance Monitoring for Extraction Wells

Upon installation of extraction wells EW-1 through EW-15, a comprehensive round of groundwater sampling

was performed in June 1999 to establish "baseline" conditions for groundwater quality in the monitoring and extraction wells prior to extraction well system startup (see Pre-Startup and Startup Performance Monitoring Report for Remedial Action at Operable Unit 1 and Operable Unit 4, EA Engineering, 1999). Figure 7 provides the location of the subject extraction wells, which were all installed onbase as part of the interim remedy.

The primary objective of the pre-startup sampling event was to provide timely baseline data prior to startup. As a result, the analytical data from the pre-startup sampling, as well as the startup and performance monitoring discussed below, was not validated for risk assessment purposes.

A total of 36 wells were sampled as part of the startup monitoring including fourteen extraction wells (all within hydrogeologic unit B), seven monitoring wells within hydrogeologic unit A, thirteen monitoring wells within hydrogeologic unit B, and two monitoring wells installed between hydrogeologic units B and C. The analytical results for VOCs appear in Table 4 (see Pre-Startup and Startup Performance Monitoring Report for Remedial Action at Operable Unit 1 and Operable Unit 4, EA Engineering, 1999 for full results).

TCE and CCl_4 were each detected in multiple extraction wells at concentrations exceeding 1,000 ug/l. PCE was detected in multiple extraction wells at concentrations exceeding 100 ug/l. 1,1,2-TCA was detected in multiple wells at levels exceeding the MCL. Chloroform was detected in three extraction wells during the pre-startup monitoring at levels exceeding the MCL of 80 ug/l. Benzene was detected in two extraction wells at concentrations exceeding MCLs. 1,2-DCA and 1,1-DCE were each detected above the MCLs in one extraction well. No other VOCs were detected in extraction wells above MCLs. VOCs detected above MCLs in sampled monitoring wells were as follows: CCl_4, 1,1-DCE, cis-1,2-DCE, TCE, PCE, vinyl chloride and 1,1,1-TCA. Chloroform was not detected in monitoring wells at levels exceeding the MCL. Methylene chloride was frequently detected during this sampling round. However, the subject data was not validated and available information suggests the methylene chloride was a laboratory contaminant.

Startup performance monitoring was performed to evaluate VOC concentrations in Area A groundwater during the startup stages of the operation of the extraction system. Three rounds of monitoring were performed between July 1999 and September 1999 (see Pre-Startup and Startup Performance Monitoring Report for Remedial Action at Operable Unit 1 and Operable Unit 4, EA Engineering, 1999 for sample results). The sampling included the extraction wells and 25 monitoring wells. Analysis was limited to VOCs. Table 5 summarizes analyzed results for all three sampling rounds which were conducted 6, 14, and 21 days after the start of the extraction system operation.

The types, concentration, and frequency of VOC detections were similar to the previous monitoring results with one possible exception. Methylene chloride was reported in several extraction wells. As noted above, methylene chloride is a common laboratory contaminant and the analytical results were not validated for risk

assessment purposes.

Monthly performance monitoring was conducted to evaluate VOC concentrations in the groundwater during the first 3 months of operation of the extraction system, between September and November 1999, and sample results are summarized in Table 6 (see Pre-Startup and Startup Performance Monitoring Report for Remedial Action at Operable Unit 1 and Operable Unit 4, EA Engineering, 1999 for sample results). No additional contaminants were detected at concentrations exceeding MCLs as part of these sampling events.

Table 7 provides a summary of historical analytical results for selected monitoring wells within and in the vicinity of Area A, This table presents data from the investigations discussed above as well as from the perimeter monitoring program discussed in Section lll.

- Supplemental Inorganic Sampling

A supplemental sampling round was conducted in May 2000 to further evaluate inorganics in groundwater (see final RI/FS Report for Area A Groundwater, TtNUS 2000 for sample results). The interim remedy ROD identified arsenic, manganese, barium and thallium as contaminants of concern. Eighteen monitoring wells (four from unit A, 11 from unit B, and three from unit C) were sampled and analyzed for Target Analyte List (TAL) metals (total and dissolved). Samples for dissolved metals were field-filtered.

Only thallium and iron were detected at levels exceeding background concentrations and MCLs. Thallium was detected in 2 unfiltered samples at 4.3 ug/I and 5.3 ug/l, which exceeds the MCL of 2 ug/l. Thallium was not detected in filtered samples collected from the same wells. Iron was detected above the secondary MCL (SMCL - 300 ug/l) in both filtered and unfiltered wells constructed with steel casings. No wells without steel casings contained iron concentrations in excess of background levels and SMCLs.

C. Evaluation of Contaminant Data

Releases within Area A are a source of TCE in groundwater as evidenced by the TCE data presented in Section VII A. TCE concentrations attributable to Area A consistently exceed the MCL in groundwater in both hydrogeologic units A and B. However, a shallower source/plume unlikely to be attributable to Area A is located within the off-base area west of Area A as evidenced by the high concentrations of TCE found in hydrogeologic unit A well HN-52S. The TCE concentrations in Well HN-52S were twice as high as both the TCE level detected in the hydrogeologic unit B well at this location and the highest concentration detected in hydrogeologic unit A wells in the immediate vicinity of Area A.

Available data also indicates PCE has been released from Area A to groundwater. PCE has been detected in on-base extraction and monitoring wells and in nearby downgradient wells installed into hydrogeologic unit B. However, PCE levels exceeding the MCL in well HN52S within the off-base area west of Area A are

unlikely to be attributable to Area A or the Site. This is evidenced by the high concentration of PCE found in hydrogeologic unit A well HN-52S, which was approximately an order of magnitude higher than the highest PCE level detected in any wells within Area A and 2 orders of magnitude higher than the PCE level found in HN-52l, the hydrogeologic unit B well at this location.

Another indication of a second source for the PCE is a comparison of PCE and carbon tetrachloride levels within hydrogeologic unit B. Carbon tetrachloride and PCE levels in wells HN-59l, HN-14l, and HN-16l (all downgradient of Area A) are comparable, with carbon tetrachloride levels somewhat higher (average PCE concentration 85 µg/L, average carbon tetrachloride concentration 134 µg/L). These levels reflect the impacts of Area A. The concentration of PCE detected in WTMA 26 was 75 µg/L, nearly the same as the average level detected in these downgradient wells. Carbon tetrachloride, however, was not detected in WTMA 26, despite being found at higher concentrations than PCE both on-base and in the downgradient wells. Historically, trace to nondetect levels of carbon tetrachloride have been found in WTMA 26. Based on the decrease in carbon tetrachloride concentrations (from 134 µg/L to <1 µg/L) from the subject wells to WTMA 26, a substantial decrease in PCE levels would also be expected if there were no other sources of PCE. However, the level of PCE in WTMA 26 is very similar to levels detected in the subject wells. The mobility of carbon tetrachloride is greater than that of PCE; therefore, the elevated level of PCE in WTMA 26 indicates another source contributing PCE levels in WTMA 26.

Carbon tetrachloride concentrations are in excess of the MCL within and immediately downgradient of Area A in hydrogeologic unit B. Area A is the source of the carbon tetrachloride contamination based on the data gathered.

1,1-DCE levels attributable to Area A and exceeding the MCL of 7 ug/l for this compound appear in hydrogeologic unit B groundwater monitored by and in the vicinity of wells HN11l and HN-55l and in extraction wells during pre-startup sampling and performance monitoring. 1,1-DCE has been detected in these wells at levels up to 25 ug/l. However, levels of 1,1-DCE in hydrogeologic unit A well HN52S (and in the vicinity of this well) west of Area A, which have ranged up to 350 ug/l, do not appear to be attributable to releases from Area A. In addition, 1,1,1-TCA levels exceeding the MCL in HN-52S also do not appear to be attributable to Area A. 1,1,1-TCA levels in this well have ranged up to 1,000 ug/l. Concentrations of 1,1,1-TCA in wells surrounding HN-52S (HN-65l1, HN-59S, and HN-16S) ranged from not detected (HN-59S) to 98 µg/L (HN-16S). Concentrations of 1,1-DCE, a breakdown product of 1,1,1-TCA, in wells surrounding HN-52S (HN-65l1, HN-59S, and HN-16S) ranged from 0.6 pg/L (HN-59S) to 25 Fg/L (HN-65I1). 1,1,1-TCA was not detected in wells HN-59S and HN-14S, and 1,1-DCE was not detected in HN-14S; these wells are located between Area A and wells HN-16S and HN-52S. In addition, 1, 1, 1 -TCA has not been detected above 1 Fg/L in any on-base well samples. As with groundwater within hydrogeologic unit A, the highest concentrations of 1,1,1-TCA in hydrogeologic unit B have been detected in samples from off-base wells (HN-521 and WTMA 26).

1,2-DCA, which has an MCL of 5 ug/l, was detected in extraction well EW-A6 at 9 ug/I during the pre-startup extraction well sampling event of 1999 and at 17 ug/l in WMTA 26 during one of the monthly performance monitoring rounds. However, 1,2-DCA was not detected above the MCL in any monitoring wells sampled in the comprehensive Area A sampling event of 1997 and has not been detected above the MCL in any other extraction or monitoring well samples collected during performance monitoring. Based on this data, there does not appear to be a discernable plume of 1,2-DCA exceeding the MCL attributable to Area A.

Cis-1,2-DCE was detected above the MCL of 70 ug/I within hydrogeologic unit B in on-base well HN-12S during the comprehensive sampling event of 1997 and monthly performance sampling (at levels of 72 ug/I and 130 ug/l, respectively), and monitoring well HN-15S (at 230 ug/l) during pre-startup sampling. Based on this and other RI related data, it appears that cis-1,2-DCE has been released from Area A to groundwater. However, cis-1,2-DCE also has been detected in well HN-52S, west of Area A, at levels of up to 660 ug/I during monitoring round sampling events. Cis-1,2-DCE is a breakdown product of PCE. PCE levels of up to 4,800 ug/l, apparently attributable to another source, have been detected in well HN-52S. This and other RI data (see discussion above regarding non-Area A related sources of 1,1,1 -TCA and 1,1 -DCE) suggest that Area A is not the source of cis-1,2-DCE in well HN-52S.

1,1,2-TCA, chloroform, benzene and vinyl chloride have all been detected above MCLs in monitoring and/or extraction wells within or immediately downgradient of Area A. Based on available data, the reported detections of these compounds above MCLS appear to be attributable to releases from Area A.

While iron was detected above the secondary MCL (SMCL) in both filtered and unfiltered samples collected during the sampling event of May 2000, only samples collected from monitoring wells with steel casing contained levels exceeding the SMCL. Based on this information, the detected iron levels do not appear to be attributable to Area A. Thallium levels exceeding the MCL of 2 ug/I were potentially detected in 2 out of 18 unfiltered samples (levels of 4.2 ug/I in HN-15D and 5.6 ug/I in MW-E) and one filtered sample (4.8 ug/I in HN-13S). However, the detected levels, were potentially attributable to blank contamination. In addition, these reported results do not otherwise suggest the potential presence of a discernable plume of thallium in groundwater.

D. Dense Non-Aqueous Phase Liquid (DNAPL)

Within Area A, the presence of TCE in DNAPL form has been inferred based on the concentrations detected in groundwater and confirmed through dye testing performed during extraction well drilling, yield testing, and sampling activities. Based on the contaminant levels detected, TCE and PCE are the only compounds that were detected at concentrations >1% of their respective solubility limits. The maximum concentration of TCE detected in performance monitoring sampling (EA Engineering, 1999) was 280 mg/L, 25% of the solubility limit, in extraction well EWA7. Performance monitoring samples from a number of other nearby extraction

and/or monitoring wells had concentrations exceeding the 1% threshold for TCE (11 mg/L), most notably EWA4, EWA5, EWA6, EWA7, EWA9, EWA10, and HN-11I. During sampling activities performed as part of the extraction well drilling and testing activities, TCE concentrations of as high as 1,219 mg/L (in well EWA6) were detected in samples analyzed by a fixed base lab (Foster Wheeler, 1999). This concentration is above the solubility limit for TCE.

Dye testing was also performed during extraction well drilling and testing. Positive results, indicating the presence of a separate-phase liquid (i.e. DNAPL) were recorded for extraction wells EWA6, EWA7, and EWA10, confirming the presence of DNAPL in these wells. Water quality data from the wells indicates that the DNAPL is TCE. Details regarding the DNAPL testing and extraction well drilling and sampling operations are provided in the summary report for Area A extraction well installation/testing (Foster-Wheeler, 1999).

Based on the high observed dissolved concentrations of carbon tetrachloride and PCE in the same wells where the highest TCE levels were detected, there is also a possibility that either carbon tetrachloride or PCE may also be present in DNAPL form, along with TCE. Where several chemicals co-exist in DNAPL form as a mixture, the effective solubility for each chemical is influenced by the other chemicals present, with the result that the effective solubility for each chemical is reduced from its pure-phase solubility. As a result, a given dissolved concentration of a chemical that is present in a DNAPL mixture is closer to the solubility limit of that chemical than would be indicated by a comparison against the pure-phase solubility for that chemical. Since carbon tetrachloride is present at a higher dissolved concentration relative to its pure-phase solubility than PCE, it is more likely that carbon tetrachloride may also be present in DNAPL form than PCE.

Figures 13 and 14 show TCE levels in cross-section across a portion of the northern edge of Area A, immediately prior to the extraction system startup and after 3 months of operation. Zones of TCE concentration of 10,000 µg/L or greater are considered areas potentially containing TCE in DNAPL form.

The RI/FS for Area A Groundwater (TtNUS 2000) presents a detailed evaluation of the contaminant and hydrogeologic data that indicate the presence of DNAPL. Specifically, Appendix E to that report (Evaluation of the Technical Impracticability of Groundwater Restoration Area A, TtNUS 2000) presents a thorough evaluation of the site conceptual model and contaminant and hydrogeologic findings as they relate to DNAPL in on-base portions of Area A.

Data suggest that DNAPL at the Site likely exists as small, disconnected accumulations within bedrock fractures and possibly, to a lesser extent, within intergranular pores. The limited solubility of the DNAPL chemicals inhibit their release from the pockets to groundwater through dissolution. Site data indicate that the DNAPL is likely present in the bedrock matrix and that diffusion from the rock into the groundwater is limited. The fractures within the bedrock provide the primary migration route and storage for contaminants and

DNAPL retention. DNAPL was primarily found in low-yielding extraction wells EW-A6 and EW-A7. The low yields are indicative of tight fractures with low water-transmitting capacities. Some TCE (and potentially CCl_4 and PCE), in both dissolved and DNAPL phases, is also likely retained within dead-end fractures, micro-fractures, and bedding planes which have low hydraulic activity. In addition, as presented in Section VII A, sampling data suggest that there is little destructive biological degradation activity at the Site.

The maximum level of PCE detected, 4.8 mg/L, was found at off-base hydrogeologic unit A monitoring well HN-52S. As discussed previously, the general low to non-detect concentrations of PCE in hydrogeologic unit A wells nearer to the base and the order of magnitude lower levels of PCE in on-base hydrogeologic unit B wells Indicate that there is an off-base source for the PCE in HN-52S. The concentration in HN-52S indicates the presence of an off-base PCE source in potential DNAPL form. In addition to the chemical data evidence described previously, it is unlikely that PCE could have migrated from the base in DNAPL form given that there is no concrete evidence of PCE in DNAPL form within Area A, and no evidence of TCE migration in DNAPL form anywhere outside the immediate vicinity of Area A (TCE is a more mobile DNAPIL chemical than PCE, based on its lower viscosity).

E. Current Contaminant Distribution

To evaluate the current patterns of contamination and the effects of the operating interim remedy groundwater extraction system across the study area within hydrogeologic units A and B, isoconcentration maps were prepared for TCE, PCE, CCL_4 and 1,1,1-TCA, the four contaminants detected at the highest concentrations, using the most recent data available for each well (primarily month 0-3 performance monitoring data). The 1,1,1-TCA levels of concern do not appear to be attributable to Area A and will not be discussed in this section.

Within hydrogeologic unit A (Figure 15), contamination migrating from Area A is primarily TCE, as indicated by TCE concentrations of 120, 420, and 290 µg/L at wells HN-55S, HN-59S, and HN-14S, respectively. Trace to non-detect concentrations of PCE and CCL_4 were detected in these wells.

The pattern of TCE, PCE and CCL_4 contaminant distributions within hydrogeologic unit B are much different than observed for hydrogeologic unit A. As expected based on the concentrations detected within Area A, the TCE plume is the most extensive within hydrogeologic unit B, projected to extend across most of the study area (Figure 16). The extent and/or magnitude of the carbon tetrachloride plume is much smaller in comparison, with trace to non-detect levels found beyond well HN-16l. The projected areal extent of the PCE plume within hydrogeologic unit B is similar to the TCE plume but PCE levels are generally an order of magnitude or more lower that corresponding TCE levels. Maximum concentrations of TCE (170,000 µg/L), CCL_4 (5,500 µg/L), and PCE (510 Fg/L) found.within hydrogeologic unit B were detected in on-site extraction

wells EWA6 and EWA7, located adjacent to one another within Area A. The contaminant plumes are migrating to the north and northwest, in the direction of groundwater flow.

Although, as indicated above, the main hydrogeologic unit B TCE, PCE, and CCL_4 plume appears to be migrating north and northwest from Area A, the operating interim remedy extraction system has effectively contained the source of this plume and data indicates that contaminant levels immediately downgradient of the source area have declined since the system began operating. Section VI presents groundwater elevation data that demonstrates that the operation of the interim remedy extraction system has altered groundwater flow patterns and has created an inward gradient within this source area (see Figures 8 and 9). The contaminant patterns shown on Figures 16 and 17 closely resemble the groundwater gradients within this area.

Contaminant trend data for extraction and monitoring wells within Area A also indicate that the interim remedy extraction system is containing the Area A groundwater contamination source and that downgradient contamination levels are decreasing. Table 8 shows TCE trends over the first 3 months of the performance monitoring TCE concentrations from the pre-startup monitoring (Day -3) are provided for further comparison. This table shows that TCE levels in on-base wells remained generally the same and in some cases increased over time Generally, TCE concentrations were the highest in the extraction wells (which are completed in hydrogeologic unit B), lower within hydrogeologic unit B monitoring wells, and the lowest within hydrogeologic unit A monitoring wells. Outside of Area A, especially in hydrogeologic unit B, TCE levels appear to be decreasing as a result of the extraction system operation as indicated by the overall trends for wells HN-14l, HN-16lI. HN-52l and D, HN-59l, and WW-1.

F. Contaminant Migration

Migration of contaminants in groundwater within and downgradient of Area A is influenced by several factors. Groundwater (and contaminant) migration occurs primarily within interconnected networks of fractures within the rock mass. Lateral migration of groundwater within hydrogeologic units A and B is primarily to the north-northwest through the shallow bedrock units that underlie the study area, in the direction of bedrock dip. Large volume pumping of groundwater from production well WTMA 26, located north of Area A, influences the local groundwater flow pattern in these two groundwater flow zones.

The vertical migration of dissolved contaminants within the bedrock aquifer is expected to be limited by the presence of semi-confining units of siltstone/mudstone that are laterally persistent on a local scale, and the presence of significant upward vertical gradients from deep zones to intermediate and shallow zones of preferential flow (primarily sandstone units). In the vicinity of the study area, little or no downward vertical migration of the dissolved contamination is expected from hydrogeologic units A and B to deeper hydrogeologic flow zones.

The structural dip of the bedrock in Area A to the north-northwest could potentially influence the migration of any DNAPL present. Field evidence indicates that TCE and possibly PCE and CCl_4 is present in the form of a DNAPL within a restricted area in the northwest corner of Area A (see Section Vll B).

WTMA 26 is located approximately 1,900 feet due north of Area A along Ivyland Road. This 10-inch-diameter well is 250 feet deep, is cased to a depth of 70 feet, and pumps at an average rate of approximately 250 gpm. While in operation this well captures the groundwater migrating from the Area A vicinity, as well as pulling in groundwater from other nearby areas.

VII. CURRENT AND POTENTIAL FUTURE LAND AND RESOURCE USES

Area A groundwater underlies the northwestern portion of the NAWC, as well as an off-base area to the north and northwest of NAWC. On-base, Area A groundwater underlies the groundwater treatment plant, extraction wells, parking lots, paved roads, two concrete-lined basins, and maintained lawn. A portion of this area is designated for transfer to the Warminster Township Municipal Authority (WTMA) under either an economic development conveyance (EDC) or public benefit conveyance (PBC). The portion of the property with the groundwater treatment plant, the extraction wells and the area immediately downgradient of those wells is being retained by the Navy.

The on-base portion of the property to be transferred and underlain by Area A groundwater has been targeted by an approved re-use plan prepared by the Land Reuse Authority (LRA) for industrial use.

Off-base areas underlain by Area A groundwater consist of property used for industrial purposes and a wooded lot.

WTMA operates a supply well located about 1900 feet north of Area A and intercepts Area A groundwater. As such Area A groundwater is considered part of a class IIA aquifer under the EPA Groundwater Protection Strategy. No other existing supply wells are known to be in use on property underlain by Area A groundwater.

IX. SUMMARY OF SITE RISKS

The human health risks associated with potential exposure to Area A groundwater have been evaluated as part of the RI for Area A groundwater (TtNUS, 2000). Area A groundwater is hydraulically connected with an operating municipal supply well. As such, the human health risk assessment performed under the RI assumed that Area A groundwater may potentially be used by residents for domestic purposes.

The Interim RI and Interim Remedy ROD present the baseline risk assessment for Area A groundwater. The final RI for Area A Groundwater presents a qualitative risk assessment that compares groundwater quality data generated since the Interim RI to MCLs.

A. Summary of Interim Remedy ROD Human Health Risk Assessment

A human health risk assessment for Area A groundwater was initially performed as part of the Interim RI and conclusions regarding the estimated human health risks are presented in the Interim Remedy ROD for OU-1. The Interim Remedy ROD estimated that Area A groundwater presented an incremental carcinogenic risk of up to 9.9×10^{-4}, while the noncarcinogenic risk was estimated to correspond to a Hazard Index of up to 93. EPA considers the acceptable carcinogenic risk range to be from 1×10^{-4} to 1×10^{-6}, while any noncarcinogenic risk corresponding to a Hazard Index of greater than 1 is considered unacceptable. The primary contributors to the carcinogenic risk were identified as TCE, CCl_4, PCE, 1,1-DCE, 1,2-DCA, chloroform, vinyl chloride, and arsenic. The primary contributors to the non-carcinogenic risk were identified as TCE, CCl_4, PCE, cis-1,2-DCE, arsenic, barium, manganese and thallium. In addition, the Interim RI found that TCE and PCE exceeded MCLs in multiple well locations, while CCl_4, vinyl chloride, 1,2-DCE, cadmium, manganese, nickel, arsenic, and barium each exceeded MCLs at one well location.

The Interim Remedy ROD indicated that the full nature and extent of contamination was not completely determined for Area A groundwater, and required that additional investigations and sampling be conducted to support the selection of a final remedial action.

B. Final Risk Assessment

A final risk assessment for Area A groundwater has been performed using data generated since the interim RI.

- Identification of Contaminants/Chemicals of Potential Concern

The final RI includes a qualitative risk assessment for organics which compares maximum VOC concentrations detected in monitoring and extraction wells to MCLs. This comparison was performed to identify VOCs detected above MCLs and thus contaminants/chemicals of potential concern (COPC) in Area A groundwater. In addition, VOCs detected at concentrations which present a carcinogenic risk greater than 1×10^{-4} (per EPA Region 3 Risk-Based Concentration (RBC) guidance) are also identified as COPCs even if there is no MCL exceedance. The RI also includes a qualitative risk assessment for the inorganics which compares maximum detected concentrations to site background concentrations and MCLs.

The final risk assessment for organics in Area A groundwater has been performed using the organic analytical data generated during the comprehensive sampling event of 1997/1998. This data was validated for risk assessment purposes. Tables 10, 11, and 12 summarize the selection of COPCs for hydrogeologic units, A, B, and C using this analytical data. Per Table 10, the maximum detected concentrations of 1,1,1-TCA, 1,1-DCE, CCl_4, PCE, and TCE were in excess of MCLs for at least one monitoring well in hydrogeologic unit A and are COPCs. Per Table 11, the maximum detected concentrations of 1,1,2-TCA, 1,1-DCE, benzene, CCl_4, cis-1,2-DCE, PCE, TCE, and vinyl chloride were in excess of MCLs for at least one monitoring well in hydrogeologic unit B and are COPCs. Per Table 12, no COPCs were identified for hydrogeologic unit C. Only iron was detected above background and MCLs during this sampling event.

Because of the limited inorganic data gathered by this sampling event, subsequent sampling for metals was conducted in May 2000. The data set from May 2000 was evaluated to determine the inorganic COPCs for Area A groundwater. Tables 13 and 14, present the results of this evaluation. Iron and thallium were identified as COPCs in both unfiltered and filtered groundwater.

Table 9 summarizes a selection of COPCs using performance monitoring data collected during 1999. This is the most recent data available for the wells evaluated but the data was not validated for risk assessment purposes. The maximum detected concentrations of CCl_4, PCE, and TCE were in excess of MCLs in the extraction wells. The maximum detected concentrations of 1,1-DCE, cis-1,2-DCE, PCE, TCE, 1,1,1-TCA, and vinyl chloride were in excess of their respective MCLs for hydrogeologic unit A. The maximum detected concentrations of CCl_4, 1,2-DCA, 1,1-DCE, cis-1,2-DCE, PCE, 1,1,2-TCA, and TCE were in excess of their respective MCLs for hydrogeologic unit B. The maximum detected concentration of TCE was in excess of the MCL for hydrogeologic unit C.

C. Contaminants of Concern (COCs) in Area A Groundwater

Per section VII of this ROD, certain identified COPCs are unlikely to be attributable to releases at Area A or the Site or otherwise should not be considered COCs. 1,1,1-TCA levels exceeding MCLs are unlikely to be attributable to releases from Area A. Therefore, 1,1,1-TCA is not a COC. There does not appear to be a discernable plume of 1,2-DCA exceeding the MCL attributable to Area A. In this case, 1,2-DCA is not a COC. While TCE, PCE, 1,1-DCE and cis-1,2-DCE are COCs, it is notable that certain detected levels of these compounds above MCLs are unlikely to be attributable to Area A. Although chloroform was not detected above MCLs during the 1997/1998 and performance monitoring events, chloroform was detected at levels above the MCL during extraction well pre-startup monitoring. Chloroform was also identified as a COC in the interim remedy ROD. Finally, neither iron nor thallium are considered COCs based on Section VII of this ROD.

Based on the above, the following compounds are considered COCs in Area A groundwater: TCE, PCE, CCL_4, 1,1-DCE, cis-1,2-DCE, 1,1,2-TCA, chloroform, benzene and vinyl chloride.

Any potential impacts of Area A groundwater on surface water, sediment and/or associated environmental receptors are addressed under Operable Unit 9 (OU-9), which consists of Area A soils and surface water/sediment potentially impacted by Area A. The ROD for OU-9 has been issued and found no evidence that Area A groundwater presents an unacceptable risk to the environment.

D. Conclusions

Contaminated groundwater attributable to releases from Area A presents an unacceptable risk to human health. TCE, PCE, CCL_4, 1,1-DCE, cis-1,2-DCE, 1,1,2-TCA, chloroform, benzene, and vinyl chloride have been determined to present an unacceptable risk and are contaminants of concern in Area A groundwater. Area A groundwater is used for water supply purposes and is classified as a Class IIA aquifer under the EPA Groundwater Protection Strategy.

Actual or threatened releases to Area A groundwater, if not addressed by a remedial action to be selected in this ROD, may present an imminent and substantial endangerment to human health or welfare or the environment.

E. Remedial Action Objectives

The Navy has implemented the interim remedy for OU-1 that was selected in an interim remedy ROD issued in September 1993. The objective of the interim remedy was to minimize migration of contaminated groundwater attributable to Area A in overburden and shallow bedrock. The remedial action objectives for the final remedy for OU-1A, as selected in this ROD, are as follows:

- Prevent further migration of Area A groundwater that presents an unacceptable risk.

- Prevent the use of contaminated Area A groundwater that presents an unacceptable risk.

- Eliminate the unacceptable risk to human health posed by Area A groundwater where technically practicable. This unacceptable risk should be eliminated by reducing COCs in Area A groundwater to COC-specific remedial action levels. The remedial action level for each COC is the MCL for each COC. The remedial action levels in this case are as follows: TCE - 5 ug/l; PCE - 5 ug/l; CCL_4- 5 ug/l; 1,1 -DGE - 7 ug/l; cis-1,2-DCE - 70 ug/l; 1,1,2-TCA - 5 ug/l; vinyl chloride - 2 ug/l; chloroform 80 ug/l;

and benzene - 5 ug/l.

X DESCRIPTION OF ALTERNATIVES

A detailed analysis of possible remedial alternatives for OU-1A is presented in the Final Area A Groundwater RI/FS Report. The detailed analysis was conducted in accordance with the U.S. EPA document entitled *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* and the National Oil Hazardous Substances Pollution Contingency Plan.

As indicated in Section VII, Area A groundwater contains an area of DNAPL. This area has been referred to as the DNAPL zone. The data from this area and areas immediately downgradient of Area A have been evaluated to determine the technical practicability of attaining remedial action levels in Area A groundwater and to establish remedial strategies for this area. This evaluation is presented in a report entitled Evaluation of the Technical Impracticability of Groundwater Restoration Area A, Former NAWC Warminster (TtNUS, 2000). This report, issued in May 2000 and included as an appendix to the final Area A Groundwater RI/FS, was prepared in accordance with the U.S. EPA "Guidance for Evaluating the Technical Impracticability of Ground-Water Restoration"; Interim Final, OSWER Directive 9234.2-25, September 1993.

Based on sampling data and hydrophobic dye testing, the presence of TCE in DNAPL form has been confirmed within Area A, centered around extraction wells EW-A6, EW-A7, and EW-A10. Although present at much lower dissolved concentrations relative to their pure-phase solubilities, CCl_4 and/or PCE may also potentially exist in DNAPL form at the site, as a mixture with TCE. The DNAPL zone extends within the fractured bedrock unit underlying Area A to a depth of approximately 70 feet and occupies a circular area about 80 feet in diameter.

The Navy has implemented an interim remedy groundwater pump and treat system within Area A. Hydraulic and chemical data gathered since the startup of the interim remedy extraction system indicate that the extraction system when operational is successfully containing the portion of the dissolved plume located in the immediate vicinity of Area A. Detections of DNAPL have been limited to the immediate vicinity of extraction wells EW-6, EW-7, and EW-10, indicating that DNAPL has not migrated from the immediate site area.

Potential remedial technologies were evaluated in terms of their ability to cleanup the DNAPL zone. The results of this evaluation determined that extraction wells were found to be effective in restricting the migration of the dissolved contaminant plume in the immediate vicinity of the DNAPL zone but would not be effective in the complete capture and removal of the DNAPL. The evaluation also determined that other technologies would not be technically practicable to implement in the Area A DNAPL zone due to the depth (70 feet below

ground surface) and the presence of fractured bedrock. The time required for complete dissolution of the DNAPL and subsequent restoration of the groundwater utilizing a groundwater pump and treat system was estimated to be in excess of 200 years.

In accordance with CERCLA and Section 300.430(a)(iii)(F) of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), the US EPA "expects to return usable ground waters to their beneficial uses wherever practicable, within a timeframe that is reasonable given the particular circumstances of the site." The document "Guidance for Evaluating the Technical Impracticability of Ground-Water Restoration (EPA, 1993) states that "... very long restoration timeframes (e.g., longer than 100 years) may be indicative of hydrogeologic or contaminant-related constraints to remediation."

In light of the estimated time for site cleanup and the technical constraints regarding the ability to remove or otherwise cleanup the DNAPL at the site, a Technical Impracticability Waiver (TIW) for the DNAPL zone at the site is warranted. The applicable or relevant appropriate requirements (ARARs) that are to be waived within the DNAPL zone (also referred to as the TI Zone) include the following:

Federal Safe Drinking Water Act, 40 CFR 141.61-62
PA Safe Drinking Water Regulations, 25 PA Code, Chapter 109

The waiver of ARARS applies only to the compounds present in DNAPL form (TCE, and potentially carbon tetrachloride and/or PCE) and only within the zone of DNAPL presence (TI Zone). ARARS for other site-related contaminants present in groundwater both within and outside of the TI Zone, and for dissolved, site-related DNAPL chemical concentrations present outside of the TI Zone are not waived.

The TI Zone includes an area of approximately 80 feet in diameter and a depth from the water table to 70 feet below ground surface. The TI Zone is depicted in Figure 18.

Due to the technical impracticability of complete restoration of groundwater within a reasonable timeframe because of the presence of DNAPL at the site, an alternative remedial strategy must be employed to address the groundwater contamination. As per EPA guidance (Guidance for Evaluating the Technical Impracticability of Ground-Water Restoration; Interim Final, OSWER Directive 9234.2-25, September 1993), the alternative remedial strategy should have three components: exposure control, source control, and aqueous plume remediation. The following alternatives were developed and evaluated against these requirements along with those required by the NCP.

Alternative 1: No Action

This alternative is required under CERCLA to establish a basis for comparison with other alternatives. Under this alternative, the existing groundwater extraction and on-site treatment systems would no longer be operated and the current groundwater monitoring program would be discontinued. Also under this alternative, Area A groundwater would be available for unrestricted use.

There are no costs associated with this No Action alternative and it could be implemented immediately.

Alternative 2: Existing Extraction, Treatment and Discharge System; Institutional Controls; and Groundwater Monitoring

Alternative 2 would consist of five major components: (1) existing groundwater extraction system, (2) existing groundwater treatment, (3) existing groundwater discharge, (4) institutional controls, and (5) groundwater monitoring

Component 1 Existing Groundwater Extraction System

This component would use the existing interim remedy Area A groundwater extraction system to contain the source area (DNAPL zone), contain/remediate the source area groundwater dissolved contaminant plume and remediate a portion of the downgradient groundwater contaminant plume. The existing pumping of WTMA 26 would capture and remediate the balance of the downgradient groundwater contaminant plume.

Existing extraction wells EW-A6, EW-A7and EW-A10, with an aggregate pumping rate in the range of 5 to 7 gallons per minute (gpm), would be used primarily to contain the DNAPL source area. Existing extraction wells EW-A1 to EW-A5, EW-A8, EW-A9, EW-A11 to EW-A13 and EW-A15, with an aggregate pumping rate of approximately 35 gpm, would be used to both contain the DNAPL source area and contain/remediate the source area groundwater dissolved contaminant plume. Existing extraction EW-A18, with a pumping rate of up to 10 gpm, and WTMA 26, with a pumping rate of approximately 250 gpm, would capture and remediate the balance of the downgradient groundwater contaminant plume.

The wells of the existing Area A groundwater extraction system are completed within and draw water primarily from hydrogeologic unit B. They also extract some groundwater from hydrogeologic unit A. WTMA 26 is completed across and draws water from hydrogeologic units A and B.

The water from the existing Area A groundwater extraction system is conveyed by a gravity collector to the existing in-ground sump of the Area A Transfer Station. From this sump the extracted groundwater is pumped to the existing groundwater treatment system (GWTS).

Component 2: Existing Groundwater Treatment System

This component would consist of continued treatment of extracted Area A groundwater in the existing interim remedy GWTS. This component would include operation and maintenance of the existing system and monitoring of its performance.

This system is designed to treat 130 gpm of groundwater and consists of the following sequence of unit processes:

- Equalization, pH Adjustment, and Chemical Oxidation and Precipitation
- Coagulation/Flocculation and Clarification
- Sand Filtration
- pH Adjustment/Neutralization
- Air Stripping with Off-Gas Treatment
- Liquid-Phase Granular Activated Carbon (GAC) Adsorption
- Sludge Thickening and Dewatering

At present, approximately 114 gpm, including 40 gpm from Area A and 74 gpm from Area D, undergoes this full sequence of treatment. Approximately 31 gpm of Area C groundwater bypasses the entire front-end of the GWTS and is only treated with liquid-phase GAC adsorption. In the very near future, Area D groundwater may also by-pass the front-end of the GWTS and, as previously mentioned, an additional 10 gpm of Area A groundwater may be extracted and treated. This will leave the entire front end of the GWTS, with a design capacity of 130 gpm, to treat only 50 gpm of Area A groundwater.

The raw groundwater enters the existing GWTS through a 9,000-gallon Equalization Tank equipped with a 3 horsepower (HP) Equalization Tank Mixer. In this tank, the groundwater from Area A is blended with that extracted from Areas B and C, the pH is adjusted to 8.5 to 9.0 with caustic soda, and hydrogen peroxide is added for the oxidation and precipitation of iron and manganese.

The equalized and chemically-treated groundwater is transferred to an Inclined Plate Separator System by one of two 130 gpm Equalized Transfer Pumps. The Inclined Plate Separator System consists of a 50 -gallon agitated Flash-Mix/Flocculator Tank followed by a 1,000 square feet (ft^2) Inclined Plate Separator. A polyelectrolyte solution is added in the Flash-Mix/Flocculator Tank to coagulate and flocculate the suspended solids contained in the raw groundwater, including the iron and manganese precipitated in the Equalization Tank. These suspended solids are then removed by gravity sedimentation in the Inclined Plate Separator.

The clarified groundwater flows by gravity from the Inclined Plate Separator to an 8-foot diameter Continuous Backwash Sand Filter where residual suspended solids are removed and concentrated in a 15 gpm backwash

stream which is either recycled to the Equalization Tank for re-processing (normal mode) or transferred to the Sludge Thickener-Holding Tank (optional mode).

The filtered groundwater flows by gravity from the continuous Backwash Sand Filter to an agitated 650 -gallon Neutralization Tank where its pH is adjusted to neutral (7.0) by controlled addition of hydrochloric acid.

The neutralized groundwater flows, still by gravity, from the Neutralization tank to a 3-tray low-profile Air Stripper System where it encounters a 900 cubic foot per minute (cfm) counter-current of air as it cascades down from tray to tray. This results in a violent frothing action which effectively removes chlorinated VOCS from the groundwater. Prior to venting to the atmosphere, the offgas from the Air Stripper System is treated through an Air Stripper Emission Control System consisting of two vapor-phase 2,500-pound GAC adsorption units in series. For optimum adsorption efficiency, the humidity of the Air Stripper System offgas is lowered to approximately 50-percent by a 25-Kilowatt (Kw) Air Stripper Exhaust Heater located immediately ahead of the Air Stripper Air Emission Control System.

The air-stripped groundwater collects in a sump at the bottom of the Air Stripper System and is transferred from there to a Granular Carbon Adsorber System by a 130 gpm Air Stripper Effluent Pump. The Granular Carbon Adsorber System consists of two liquid-phase 20,000-pound GAC adsorption units in series which remove remaining organic COCs from the groundwater and constitute the final treatment step of the GWTS.

Settled sludge is periodically transferred from the bottom of the Inclined Plate Separator to an 8-foot diameter Sludge Thickener- Holding Tank by a 10 gpm Separator Underflow Pump. As previously noted, the Sludge Thickener-Holding Tank may also receive the backwash stream from the Continuous Backwash Sand Filter. In the Sludge Thickener-Holding Tank the solids content of the sludge is increased by gravity sedimentation from approximately 0.5 percent (by weight) to approximately 3.0 percent (by weight). Thickened sludge is periodically transferred from the bottom of the Sludge Thickener-Holding Tank to a 10 cubic feet (ft^3)recessed plate type Filter Press by a 20 gpm Filter Press Feed Pump. In the Filter Press, the solids content of the thickened sludge is increased from approximately 3.0 percent by weight to 25- to 35-percent (by weight) to form a solid cake which can be hauled away for appropriate disposal. Supernatant water from the Sludge Thickener-Holding Tank and filtrate water from the Filter Press are collected in an agitated 1,000-gallon Supernatant-Filtrate Recycle Tank and returned from there to the Equalization Tank by a 15 gpm Supernatant-Filtrate Recycle Pump.

Component 3: Existing Discharge of Treated Groundwater

This component would consist of the continued discharge of the treated Area A groundwater from the existing GWTS to an existing interim remedy chlorine contact chamber and to Outfall 001 through the existing pipeline

to Little Neshaminy Creek. This component would also include regular monitoring and reporting of the quality of discharged water.

Component 4: Institutional Controls

Institutional controls would be implemented to prevent the use of Area A groundwater as long as it presents an unacceptable risk and to protect the integrity and effectiveness of the extraction well network. The institutional controls addressing current NAWC property would consist of restrictions to be included in deeds entered into for transfer of the property. The controls for current off-base property in Warminster Township would consist of the continued enforcement of a municipal ordinance which regulates well drilling. The controls for current off-base property in Ivyland Borough would consist of the enforcement of a well drilling regulation ordinance to be promulgated by Ivyland Borough.

Component 5: Groundwater Monitoring

Groundwater monitoring would consist of regularly collecting water level measurements and analyzing groundwater samples both from within and outside the contaminant plume to assess progress of remediation and to evaluate contaminant migration.

For the purposes of the FS and this ROD, it is estimated that monitoring would consist of collecting samples from 55 existing wells and analyzing them for TCL VOCs. For costing purposes, it is assumed that monitoring would be performed over a period of 30 years and that sampling frequency would be quarterly for the first year, semi-annual for the next two years, and annual for the remaining 27 years.

Reviews would be performed every 5 years to evaluate site status, assess the continued adequacy of remedial activities and determine whether further action is necessary.

The groundwater rnonitoring component would also include maintenance of the monitoring wells. In case of change of site ownership during the course of remedial activities, provisions would be incorporated into the property transfer clocuments to ensure that monitoring would continue.

The estimated costs for Alternative 2 are:

- Capital Cost: $8,000
- 30-Year Net Present Worth (NPW) of O&M Cost: $5,036,000
- 30-Year NPW: $5,044,000

Alternative 3: Modified Extraction, Treatment and Discharge System; Institutional Controls; and Groundwater Monitoring

Alternative 3 would consist of the following five major components: (1) existing and new groundwater extraction, (2) existing and new groundwater treatment (3) existing and new groundwater discharge, (4) institutional controls, and (5) groundwater monitoring.

Component 1: Modified Groundwater Extraction System

This component would use the existing interim remedy groundwater extraction system and three new extraction wells to contain the source area (including the DNAPL zone) and capture/remediate a portion of the downgradient groundwater contaminant plume. The existing pumping of WTMA 26 would capture and remediate the balance of the downgradient contaminant plume.

Existing extraction wells EW-A6, EW-A7, and EW-A10, with an aggregate pumping rate in the range of 5 to 7 gpm, would be used primarily to contain the DNAPL source area. Existing extraction wells EW-A1 to EWA5, EW-A8, EW-A9, EW-A11 to EW-A13, and EW-A-15, with an aggregate pumping rate of approximately 35 gpm, would be used to both contain the DNAPL source area and contain/remediate the source area groundwater dissolved contaminant plume. Extraction well EW-A18, with a pumping rate of up to 10 gpm, and three new extraction wells, with an aggregate estimated pumping rate of approximately 150 gpm, would be used to capture and remediate the downgradient groundwater contaminant plume. The existing pumping of WTMA 26 would capture and remediate the balance of the downgradient groundwater contaminant plume.

The wells of the existing interim remedy Area A groundwater extraction system are completed within and draw water primarily from hydrogeologic unit B. They also extract some groundwater from hydrogeologic unit A. WTMA 26 is completed across and draws water from hydrogeologic units A and B. The new groundwater extraction wells would be installed to an average depth of approximately 200 feet bgs. A 50 -gpm submersible centrifugal pump equipped with level controls would be installed in each new extraction well. Each of these pumps would be connected to a new collector system which would convey the extracted groundwater to the existing Area A Transfer Station sump. From this sump, the extracted groundwater would be pumped to the existing GWTS.

To accommodate the increased flow of extracted groundwater, the size of the Area A Transfer Station sump would be increased to 2,000 gallons, the two existing Area A transfer pumps would be replaced by two new 200 gpm submersible centrifugal transfer pumps, and a new 6-inch transfer pipe would be installed between the Area A Transfer Station and the GWTS.

Approximate locations for the groundwater extraction wells are shown on Figure 19.

Component 2: Modified Groundwater Treatment System

This component would consist of modifications to the existing GWTS to treat the additional flow of groundwater extracted from Area A and the operation and maintenance of this modified system. This component would also include monitoring the performance of the modified GWTS. As with Alternative 2, this component also relies on the continued operation of the air stripping system at the WTMA 26 wellhead.

The modified GWTS would consist of all the same sequence of unit processes as currently in place for the existing system described for Alternative 2.

As discussed earlier, the entire front end of the GWTS, including all unit processes except the liquid-phase GAC adsorption, will shortly have available approximately 80 gpm of extra capacity which could be used to treat additional Area A groundwater. Because all of the front-end unit processes, except the Air Stripper System and Air Stripper Exhaust Heater, have been conservatively designed, it is anticipated that they could accept and effectively treat the full 150 gpm additional flow of Area A groundwater with only relatively minor modifications, such as replacement of transfer pumps and piping as may be required to handle the additional hydraulic load. Therefore, the only significant modification to the existing GWTS would be the replacement of the current Air Stripper System and Air Stripper Exhaust Heater with larger units. It is anticipated that the existing Air Stripper Emission Control System would be capable of receiving and effectively treating the increased offgas flow from the new Air Stripper System.

Because the hydraulic and treatment capacity of the existing Granular Carbon Adsorber System at the polishing end of the GWTS is approximately 300 gpm, it could also accept and treat effectively the increased Area A groundwater flow, as well as the groundwater extracted from Areas C and D.

Component 3: Modified Discharge of Treated Groundwater

This component would be identical to Component 3 of Alternative 2, except for the increased discharge flow of treated groundwater.

Component 4: Institutional Controls

This component would be identical to Component 4 of Alternative 2.

Component 5: Groundwater Monitoring

This component would be identical to Component 5 of Alternative 2, except that groundwater samples would be collected from a total of 58 wells, including 55 existing wells and the 3 new extraction wells.

The estimated costs for Alternative 3 are:

- Capital Cost: $936,000
- 30-Year NPW of O&M: 5,605,000
- 30-Year NPW: 6,541,000

XI SUMMARY OF THE COMPARATIVE ANALYSIS

The remedial alternatives described in Section X were evaluated in the Feasibility Study against nine criteria identified in the NCP and the Alternative Remedial Strategy Components identified in Section X.

D. Overall Protection of Human Health and the Environment

Overall protection of human health and the environment addresses whether each alternative provides adequate protection of human health and the environment and describes how risks posed through each exposure pathway are eliminated, reduced or controlled, through treatment, engineering controls, and/or institutional controls.

Alternatives 2 and 3 would be protective of human health and the environment, even though contamination would remain in the DNAPL zone. Further expansion of the downgradient contaminant plume would be prevented and contaminants of concern outside the TI Zone would be restored to remedial action levels.
Groundwater use would be restricted and monitoring would evaluate the progress of remediation. Alternative 3 would be somewhat more protective than Alternative 2 as it would involve a more aggressive extraction scheme, which would reduce contaminant migration toward the area around WTMA 26.

Alternatives 2 and 3 would accomplish exposure control through institutional controls such as deed restrictions and municipal ordinances that would prohibit groundwater use which presents an unacceptable risk.

Source control in the TI Zone would be implemented under both Alternatives 2 and 3 by continued operation of the interim remedy extraction well system. This system provides hydraulic containment of the TI Zone and will permit the restoration of the aqueous plume outside of the TI Zone by cuffing off and isolating the source of contamination.

Alternatives 2 and 3 equally address restoration of the aqueous plume through the operation of an extraction system outside of the TI Zone and through the existing operation of WTMA 26. Should Warminster Township discontinue the operation of WTMA 26 for public water supply purposes, a determination would be made regarding the use of that well or a different well(s) to capture and contain contaminants of concern in the downgradient plume. Under the terms of a 1997 agreement between the U.S. and WTMA, WTMA would provide the Navy a 9-month notice prior to a proposed discontinuation of operation.

Alternative 1 would not provide protection of human health and the environment because uncontrolled sources of contaminants would remain in groundwater and contribute to migration. Also, use of groundwater would not be restricted, resulting in potentially unacceptable risks. DNAPL, a potential principal threat waste, would not be addressed by Alternative 1.

B. Compliance with ARARs

Section 121(d) of CERCLA, 42 U.S.C. § 9621(d), and Section 300.430(f)(1)(ii)(B) of the NCP require that remedial actions at CERCLA sites at least attain legally applicable or relevant and appropriate Federal and State requirements, standards, criteria, and limitations which are collectively referred to as "ARARs", unless such ARARs are waived under CERCLA Section 121(d)(4).

Under CERCLA Section 121(d)(4), the U.S. EPA may waive compliance with an ARAR if one of the following conditions can be demonstrated:

- The remedial action selected is only part of a total remedial action that will attain the ARAR level or standard of control upon completion;
- Compliance with the requirement will result in greater risk to human health and the environment than other alternatives;
- Compliance with the requirement is technically impracticable from an engineering perspective;
- The remedial action selected will attain a standard of performance that is equivalent to that required by the ARAR through the use of another method or approach;
- With respect to a state requirement, the state has not consistently applied the ARAR in similar circumstances at other remedial actions within the state; or
- Compliance with the ARAR will not provide a balance between protecting public health, welfare, and the environment at the facility with the availability of Superfund money for response at other facilities (fund-balancing). This condition only applies to Superfund-financed actions.

As described in Section X and as detailed in the final RI/FS for Area A Groundwater, compliance with drinking water ARARs within the TI Zone is technically impracticable. Because of this the following ARARs are waived

for that area contained within the TI Zone as depicted on Figure 18:

Federal Safe Drinking Water Act 40 CFR 141.61-62
PA Safe Drinking Water Regulations 25 PA Code, Chapter 109

The waiver of these ARARs applies only to the chemicals present in DNAPL form (TCE, and potentially carbon tetrachloride and/or PCE) and only within the zone of DNAPL presence (TI Zone). ARARs for other site-related contaminants present in groundwater both within and outside of the TI Zone, and for dissolved, site-related DNAPL chemical concentrations present outside of the TI Zone are not waived.

Alternatives 2 and 3 would eventually comply with chemical-specific ARARs, such as MCLs, except in the DNAPL source area. Alternatives 2 and 3 would achieve this compliance within approximately the same time frame. Alternatives 2 and 3 would also comply with location- and action-specific ARARs. In the source area, the presence of DNAPL in a fractured bedrock environment makes compliance with chemical-specific ARARs impracticable from an engineering point of view. However, both Alternative 2 and 3 equally comply with the requirement to maintain source control in the TI Zone. This would be implemented under both alternatives 2 and 3 by continued operation of the interim remedy extraction well system. This system provides hydraulic containment of the TI Zone and will permit the restoration, to ARAR and remedial action levels, of the aqueous plume outside of the TI Zone by cutting off and isolating the source of contamination.

Alternative 1 would not comply with chemical- and location-specific ARARs. Action-specific ARARs would not apply.

C. LONG-TERM EFFECTIVENESS AND PERMANENCE

Long-term effectiveness and permanence refers to expected residual risk and the ability of the remedy to maintain reliable protection of human health and the environment over time, once clean-up levels have been met. This criterion includes the consideration of residual risk that will remain following remediation and the adequacy and reliability of controls.

Alternatives 2 and 3 would provide long-term effectiveness and permanence. Although significant contamination would likely remain in the DNAPL source area, extraction and on-site treatment of contaminated groundwater will effectively prevent expansion of the downgradient Area A–related contaminant plume and help reduce contaminants of concern in the plume to remedial action levels. The residual contamination remaining in the DNAPL or TI Zone would be contained through the operation of the source control portion of the extraction system. Alternatives 2 and 3 utilize the same source control component, which is currently operational. The source control extraction system provides hydraulic containment of the source

area and will permit the restoration of the dissolved plume outside of the source area by cutting off and isolating the source area.

Alternatives 2 and 3 both include the continued pumping of WTMA 26. Should WTMA discontinue the operation of WTMA 26 for public water supply purposes, a determination would be made regarding the use of that well or a different well(s) to capture and contain contaminants of concern in the downgradient plume. Under the terms of a 1997 agreement between the U.S. and WTMA, VVTMA would provide the Navy a 9-month notice prior to a proposed discontinuation of operation.

The institutional controls component of Alternatives 2 and 3 would effectively prevent the use of Area A groundwater as long as it presents an unacceptable risk.

The long-term monitoring component of Alternatives 2 and 3 would provide an effective means of evaluating the progress of remediation and verifying that no contaminant migration is occurring.

Alternative 1 would have very limited long-term effectiveness and permanence because, even though contaminant reduction might occur due to natural processes, contaminant migration would likely continue and there would be no restriction of groundwater use. The DNAPL area would continue to act as a source of contamination for the aquifer and the dissolved plume would continue to migrate.

D. Reduction of Toxicity, Mobility, or Volume Through Treatment

Reduction of toxicity, mobility or volume through treatment refers to the anticipated performance of the treatment technologies that may be included as part of the remedy.

Alternatives 2 and 3 would achieve a significant reduction in contaminant toxicity and volume through treatment. The initial design removal rates of the groundwater extraction and treatment systems for these alternatives are 150 and 600 pounds of VOCs per year, respectively. Because the GAC used for treatment would be either incinerated or regenerated, this contaminant removal would be completely irreversible.

Alternatives 2 and 3 utilize the same source control component, which is currently operational. The source control extraction system provides hydraulic containment of the source area and prevents migration or limits the mobility of the DNAPL contained within the source area. Alternatives 2 and 3 would also achieve some reduction in contaminant mobility as they would prevent further migration of the downgradient contaminant plume through extraction and treatment.

Alternative 1 does not include treatment as a component of the remedy and therefore would not achieve any

reduction of toxicity, mobility, or volume of contaminants.

E. Short-term Effectiveness

Short-term effectiveness addresses the period of time needed to implement the remedy and any adverse impacts that may be posed to workers, the community, and the environment during construction and operation of the remedy until cleanup levels are achieved.

Alternative 2 would have minimal short-term effectiveness concerns. Any exposure of workers to contamination during operation of the existing GWTS would be minimized by utilizing appropriate personal protection equipment (PPE) and complying with site-specific health and safety procedures.

Alternative 3 would have a few more short-term effectiveness concerns than Alternative 2 because of the potential for exposure of construction workers to contaminated groundwater during the installation of the new extraction wells and modification of the existing GWTS. However, as with Alternative 2, this exposure and the attendant risks would be minimized by utilizing appropriate PPE and complying with site-specific health and safety procedures.

Alternatives 2 and 3 would not adversely impact the surrounding community or the environment. Treatment of the air stripping offgases with GAC adsorption would reduce the risk to human receptors and workers by eliminating organic vapors from the emissions.

Remedial action levels would be achieved in the downgradient contaminant plume within an estimated 11 years by both Alternatives 2 and 3. Under Alternative 3, site-related impacts to WTMA 26 would be reduced more quickly than under Alternative 2. Because of the presence of DNAPL in fractured bedrock, neither alternative is expected to achieve groundwater remedial action levels in the source area within a reasonable time frame. The source control extraction system utilized by Alternatives 2 and 3 is currently operational and provides hydraulic containment of the source area.

Implementation of Alternative 1 would not result in risks to site workers or adversely impact the surrounding community or environment since no remedial activities would be performed. However, Alternative 1 would not achieve the remedial action objectives.

F. Implementability

Implementability addresses the technical and administrative feasibility of the remedy from design through construction and operation. Factors such as availability of services and materials, administrative feasibility,

and coordination with other governmental entities are considered.

Alternative 1 would be very simple to implement since no action would occur.

Alternatives 2 and 3 would be technically implementable. Implementation of Alternative 2 would not require the installation of new extraction wells or modification of the GWTS. In this case, the existing GWTS would continue to be operated. The resources, equipment, and materials required for continued operation are readily available.

Implementation of Alternative 3 would be more complex than Alternative 2. Construction and operation of three new extraction wells and modification of the existing GWTS to increase its treatment capacity would be required. Additional extraction wells would be installed on private property, and property owner consent and easements would be required. Design, planning and additional studies would be required to locate the new extraction wells and to evaluate the impact on the existing extraction wells, WTMA 26 and contaminant sources unrelated to the Site. Transfer lines for the new extraction wells would likely require a sub-grade rail crossing which would require horizontal drilling and likely require an additional transfer sump, possibly on current private property.

Under both Alternatives 2 and 3, institutional controls would include a municipal ordinance regulating well drilling to be promulgated by Ivyland Borough. Available information indicates that such an ordinance would be promulgated.

Alternatives 2 and 3 both require an administrative TIW. The TIW applies to the DNAPL or TI Zone as described above. This TIW would waive the requirement to achieve drinking water standards for TCE, CCI_4, and PCE within the TI Zone as defined in regulations promulgated under the Federal Safe Drinking Water Act, 40 CFR 141.61-62 and PA Safe Drinking Water Regulations, 25 PA Code, Chapter 109. The evaluation and justification for a TIW was completed in May 2000 and has been included as part of the final RI/FS for Area A groundwater.

G. Cost

The capital and Operation and Maintenance (O&M) costs and Net Present Worth (NPW) of Alternatives 1, 2, and 3 are as follows.

Alternative	Capital ($)	30-year O&M ($)	30-year NPW($)
1	0	0	0
2	8,000	5,036,000	5,044,000
3	936,000	5,605,000	6,541,000

Costs have been rounded to the nearest $1,000 to reflect the preliminary nature of the estimates.

H. State Acceptance

The Pennsylvania Department of Environmental Protection, on behalf of the Commonwealth of Pennsylvania, has reviewed the information available for this site and has concurred with this ROD and the selected remedy identified below. A copy of the letter of concurrence from the Commonwealth of Pennsylvania is attached to this ROD.

I. Community Acceptance

The selected remedy was presented to the public in a public meeting along with the Proposed Plan. Comments and questions raised by members of the community are addressed in the Responsiveness Summary presented in Section XIV.

Comments received at the public meeting and during the comment period are presented in Appendix C. In selecting a final remedy, the Navy and EPA have evaluated and balanced the nine criteria discussed above.

J. Principal Threat Wastes

Soils within Area A are being addressed under OU-9. A removal action addressing soils within Area A were undertaken by the Navy between 1996 and 1999. This action involved the excavation and offsite disposal of soils from potential source areas associated with Sites 1, 2 and 3 and the former Impoundment Area within Area A. Data gathered during remedial investigations and removal actions did not identify any soils which presented a threat to groundwater quality and the soils were otherwise determined not to constitute a principle threat as defined by the NCP. However, groundwater data collected during the installation and operation of monitoring and extraction wells has identified the presence of DNAPL within Area A, which may be considered a principal threat.

This area of DNAPL contains trichloroethene (TCE) and potentially carbon tetrachloride (CCl_4) and/or tetrachloroethene(PCE) at saturation levels within the bedrock fracture network (secondary porosity) and to a lesser degree within the intergranular pores of the rock. Monitoring and extraction wells drilled within and

adjacent to Area A have delineated the DNAPL zone. This DNAPL zone is a Principal Threat Waste as defined by the NCP.

The data from this area and areas immediately downgradient of Area A have been evaluated to demonstrate the technical impracticability of attaining required groundwater remedial action levels and to establish alternative remedial strategies for this area. This evaluation is presented in a report entitled Evaluation of the Technical Impracticability of Groundwater Restoration Area A, Former NAWC Warminster (TtNUS, 2000). This report, issued in May 2000 and included as an appendix to the final Area A Groundwater RI/FS was prepared in accordance with the U.S. EPA "Guidance for Evaluating the Technical Impracticability of Ground-Water Restoration"; Interim Final, OSWER Directive 9234.2-25, September 1993.

Potential remedial technologies were evaluated in terms of their ability to cleanup the DNAPL zone. The results of this evaluation determined that extraction wells would be effective in restricting the migration of the dissolved contaminant plume in the immediate vicinity of the DNAPL zone but would not be effective in the complete capture and removal of the DNAPL. The evaluation also determined that other technologies would not be technically practicable to implement in the Area A DNAPL zone due to the depth and the presence of fractured bedrock. The time required for complete dissolution of the DNAPL and subsequent restoration of the groundwater utilizing a groundwater pump and treat system was estimated to be in excess of 200 years.

Based on this evaluation, the estimated time for site cleanup and the technical constraints regarding the ability to remove or otherwise cleanup the DNAPL at the site, a Technical Impracticability Waiver (TIW) for the DNAPL zone at the site was prepared. The TIW applies only to the chemicals present in DNAPL form (TCE, and potentially carbon tetrachloride and/or PCE) and only within the zone of DNAPIL presence (referred to as the TI Zone).

The TI Zone includes an area of approximately 80 feet in diameter and a depth from the water table to 75 feet below ground surface. The TI Zone is depicted in Figure 18.

Section 300.430(a)(iii)(A) of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) establishes the expectation that treatment will be used to address Principal Threat Wastes wherever practicable. As indicated above, an evaluation of technologies has determined that it is not technically practicable to restore the groundwater within the TI Zone to cleanup goals. However, both Alternatives 2 and 3 utilize components that contain the Principal Threat Waste, prevent migration, and treat the captured dissolved portion of the plume released by the Principal Threat Waste.

Alternatives 2 and 3 both require the continued operation of the interim remedy groundwater pump and treat system, which was implemented by the Navy within Area A in 1999. Hydraulic and chemical data gathered

since the startup of the interim Area A extraction system indicate that the extraction system installed as part of the interim remedy, when operational, is successfully containing the portion of the dissolved plume located in the immediate vicinity of Area A. Detections of DNAPL have been limited to the immediate vicinity of extraction wells EW-6, EW-7, and EW-10, indicating that DNAPL has not migrated from the immediate site area.

Both Alternatives 2 and 3 include a treatment component for removing and permanently destroying the contaminants present in the groundwater extracted from within the Principal Threat Waste area, or TI Zone. The treatment component to be used for each alternative is presented in detail under the description of Component 2 for each alternative (see Section X).

Three alternatives have been evaluated using the nine remedy selection criteria as specified by the NCP (see Sections XI A. through XI I. above). Alternatives 2 and 3 satisfy the statutory preference for treatment of Principal Threat Wastes to the extent practicable. Alternative 1 does not satisfy this statutory preference.

XII THE SELECTED REMEDY

The selected remedy, Alternative 2, consists of maintaining and operating the existing interim remedy groundwater extraction system, treating the extracted groundwater using the existing groundwater treatment system, discharging the treated groundwater through the existing groundwater treatment plant discharge and institutional controls to prevent the use of Area A groundwater as long as it presents an unacceptable risk and to protect the integrity and the effectiveness of the extraction well network. The institutional controls addressing current NAWC property shall consist of restrictions to be included in deeds entered into for transfer of the property. The controls for current off-base property in Warminster Township will consist of the continued enforcement of a municipal ordinance that regulates. well drilling. The controls for current off-base property in Ivyland Borough will consist of a well drilling ordinance to be promulgated by Ivyland Borough. Area A groundwater contamination outside the capture zone of the existing extraction well system is being captured by existing pumping of WTMA 26. A monitoring system will monitor the progress of the remediation and to ensure that migration of contamination is not occurring.

The remedial action levels for Area A groundwater address two separate areas (dissolved plume and the TI Zone) and are as follows:

Dissolved Plume

Trichloroethene (TCE) - MCL [Safe Drinking Water Act, National Primary Drinking Water Standard MCLs, 40 CFR Part 141].

Tetrachloroethene (PCE) - MCL [Safe Drinking Water Act, National Primary Drinking Water

Standard MCLs, 40 CFR Part 141].

Carbon Tetrachloride (CCl_4) - MCL [Safe Drinking Water Act, National Primary Drinking Water Standard MCLs, 40 CFR Part 141].

1,1-Dichloroethene (1,1-DCE) - MCL [Safe Drinking Water Act, National Primary Drinking Water Standard MCLs, 40 CFR Part 141].

Vinyl Chloride - MCL [Safe Drinking Water Act, National Primary Drinking Water Standard MCLS, 40 CFR Part 141].

cis-1,2-Dichloroethene (cis-1,2-DCE) - MCL [Safe Drinking Water Act, National Primary Drinking Water Standard MCLs, 40 CFR Part 141].

1,1,2-Trichloroethane (1,1,2-TCA)- MCL [Safe Drinking Water Act, National Primary Drinking Water Standard MCLs, 40 CFR Part 141].

Benzene - MCL [Safe Drinking Water Act, National Primary Drinking Water Standard MCLs, 40 CFR Part 141].

Chloroform - MCL [Safe Drinking Water Act, National Primary Drinking Water Standard MCLs, 40 CFR Part 141].

TI Zone

In accordance with CERCLA Section 121(d)(4)(C) and Section 300.430(f)(1)(ii)(C)(3) of the NCP, the following ARARs are waived for the TI Zone as described in Appendix E of the final RI/FS for Area A Groundwater (TtNUS, 2000) and depicted in Figure 18:

Trichloroethene (TCE) - MCL [Safe Drinking Water Act, National Primary Drinking Water Standard MCLs, 40 CFR Part 141].

Tetrachloroethene (PCE) - MCL [Safe Drinking Water Act, National Primary Drinking Water Standard MCLs, 40 CFR Part 141].

Carbon Tetrachloride-(CCL_4) - MCL [Safe Drinking Water Act, National Primary Drinking Water Standard MCLs, 40 CFR Part 141).

Remedial action levels established for the dissolved plume for all other contaminants of concern apply to the TI Zone.

EPA may modify this determination (a) if, as a result of a five-year review under CERCLA Section 121(c) and Section 300.430(f)(4)(ii) of the NCP, it receives information that indicates the remedy selected is no longer protective of human health and the environment, or (b) if it otherwise receives information that the remedy selected is no longer protective of human health and the environment.

A. Summary of the Rationale for the Selected Remedy

Based on available information and the current understanding of site conditions, Alternative 2 provides the best balance of the nine NCP evaluation criteria. The selected remedy will be protective of human health and the environment through both containment and treatment components to decrease contaminant concentrations to levels protective of human health where practicable. Contaminants in the DNAPL zone will be contained and migration of those contaminants will be controlled. The containment of this source area will cut off and isolate the source of contamination from downgradient portions of the aquifer. In addition, dissolved contaminants of concern attributable to Area A will be restored to remedial action levels protective of beneficial use and the unacceptable risk to human health will be eliminated.

Institutional controls will prevent the use of Area A groundwater as long as it presents an unacceptable risk. Groundwater monitoring will assess the progress and effectiveness of the selected remedy.

The selected remedy will comply with all ARARs, with the exception of those being waived in this ROD, and will restore Area A groundwater to remedial action levels protective of human health to the extent practicable. Groundwater data collected during the installation and operation of monitoring and extraction wells has identified the presence of DNAPL within Area A.

This area of DNAPL contains trichloroethene (TCE) and potentially carbon tetrachloride (CCl_4) and/or tetrachloroethene(PCE) at saturation levels within the bedrock fracture network (secondary porosity) and to a lesser degree within the intergranular pores of the rock. Monitoring and extraction wells drilled within and adjacent to Area A have delineated the DNAPL zone.

The data from this area and areas immediately downgradient of Area A have been evaluated to demonstrate the technical impracticability of attaining required groundwater remedial action levels and to establish alternative remedial strategies for this area. This evaluation is presented in a report titled Evaluation of the Technical Impracticability of Groundwater Restoration Area A, Former NAWC Warminster (TtNUS, 2000). This report, issued in May 2000 and included as an appendix to the final Area A Groundwater RI/FS was prepared in accordance with the U.S. EPA "Guidance for Evaluating the Technical Impracticability of GroundWater Restoration"; Interim Final, OSWER Directive 9234.2-25, September 1993.

Potential remedial technologies were evaluated in terms of their ability to cleanup the DNAPL zone. The results of this evaluation determined that extraction wells were found to be effective in restricting the migration of the dissolved contaminant plume in the immediate vicinity of the DNAPL zone but would not be effective in the complete capture and removal of the DNAPL. The evaluation also determined that other technologies would not be technically practicable to implement in the Area A DNAPL zone due to the depth of the DNAPL

and the presence of fractured bedrock. The time required for complete dissolution of the DNAPL and subsequent restoration of the groundwater utilizing a groundwater pump and treat system was estimated to be in excess of 200 years.

In light of the estimated time for site cleanup and technical constraints regarding the ability to remove or otherwise cleanup the DNAPL at the site, and in accordance with CERCLA Section 121(d)(4)(C) and Section 300.430(f)(1)(ii)(C)(3) of the NCP, the Navy and EPA have determined that it is technically impracticable to achieve compliance with the following chemical-specific ARARS as they apply to the DNAPL within the TI Zone:

> Trichloroethene (TCE) - MCL [Safe Drinking Water Act, National Primary Drinking Water Standard MCLs, 40 CFR Part 141].
> Tetrachloroethene (PCE) - MCL [Safe Drinking Water Act, National Primary Drinking Water Standard MCLs, 40 CFR Part 141].
> Carbon Tetrachloride (CCl_4) - MCL [Safe Drinking Water Act, National Primary Drinking Water Standard MCLs, 40 CFR Part 141].

The Commonwealth of Pennsylvania, as represented by the Pennsylvania Department of Environmental Protection (PADEP), concurs with this action. In this case, the chemical-specific requirements for these contaminants as addressed by PA Safe Drinking Water Regulations, 25 PA Code, Chapter 109, are also waived for the TI Zone.

The selected remedy will attain or comply with all other location-specific, action-specific, and other contaminant-specific ARARs as described in Section XIII.B.

The overall effectiveness of the selected remedy is proportional to the capital and O&M costs associated with implementing the remedy. These costs are reasonable compared to the effectiveness and costs afforded by other remedial options.

In addition, the selected remedy achieves the preference for treatment as a principal element to the extent practicable. The use of groundwater extraction and treatment components reduces the toxicity, mobility, and volume of contamination through the irreversible destruction of contaminants within the capture zone of the extraction well network.

The selected remedy does not result in the immediate removal of all contaminants from the Site. Therefore, the requirement for five-year reviews is included as a component to the selected remedy.

B. Description of the Selected Remedy

The major components of the selected remedy are as follows:

Component 1: Existing Interim Remedy Groundwater Extraction Well System

This component will use the existing interim remedy Area A groundwater extraction system to contain the source area (DNAPL zone), contain/remediate the source area groundwater dissolved contaminant plume and remediate a portion of the downgradient groundwater contaminant plume. The existing pumping of WTMA 26 will capture and remediate the balance of the downgradient groundwater contaminant plume.

Existing extraction wells EW-A6, EW-A7and EW-A10, with an aggregate pumping rate in the range of 5 to 7 gallons per minute (gpm), will be used primarily to contain the DNAPL source area. Existing extraction wells EW-A1 to EW-A5, EW-A8, EW-A9, EW-A11 to EW-A13 and EW-A-15, with an aggregate pumping rate of approximately 35 gpm, will be used to both contain the DNAPL source area and contain/ remediate the source area groundwater dissolved contaminant plume. Existing extraction EW-A18, with a pumping rate of up to 10 gpm, and WTMA 26, with a pumping rate of approximately 250 gpm, will capture and remediate the balance of the downgradient groundwater contaminant plume.

Component 2: Existing Groundwater Treatment

This component consists of continued treatment of extracted Area A groundwater in the existing interim remedy groundwater treatment system. This component includes operation and maintenance of the existing system and monitoring of its performance.

This system currently consists of the following sequence of unit processes:

- Equalization, pH Adjustment, and Chemical Oxidation and Precipitation
- Coagulation/Flocculation and Clarification
- Sand Filtration
- pH Adjustment/Neutralization
- Air Stripping with Off-Gas Treatment
- Liquid-Phase GAC Adsorption
- Sludge Thickening and Dewatering

Component 3: Existing Discharge of Treated Groundwater

This component consists of the continued discharge of treated Area A groundwater from the existing groundwater treatment system to an existing interim remedy chlorine contact chamber and to Outfall 001 and an existing pipeline to Little Neshaminy Creek. This component also will include regular monitoring and reporting of the quality of discharged water.

Component 4: Institutional Controls

Institutional controls will be implemented to prevent the use of Area A groundwater as long as it presents an unacceptable risk and to protect the integrity and effectiveness of the extraction well network. The institutional controls addressing current NAWC property will consist of restrictions to be included in deeds entered into for transfer of the property. The controls for current off-base property within Warminster Township will consist of the continued enforcement of a municipal ordinance which regulates well drilling. The controls for current off-base property in Ivyland Borough will consist of the enforcement of an ordinance to be promulgated by the Borough.

Component 5: Groundwater Monitoring

Groundwater monitoring will consist of regularly collecting water level measurements and analyzing groundwater samples both from within and outside the contaminant plume to assess progress of remediation and to evaluate contaminant migration.

Reviews will be performed every 5 years for 30 years, or until the groundwater is restored, to evaluate site status, assess the continued adequacy of remedial activities, and determine whether further action is necessary.

C. Performance Criteria

Components 1 and 5:

The DNAPL will be contained, the TI Zone maintained and the beneficial use of the aquifer will be restored in the remaining portion of the contaminant plume by pumping groundwater to achieve and maintain an inward and upward hydraulic gradient about the extraction wells. Portions of the plume which are not captured by the Area A interim remedy extraction well system will be captured by the pumping of WTMA 26. That portion of the Area A groundwater downgradient of the Area A extraction well system is expected to reach remedial action levels. Decreases of contamination levels will be confirmed through sampling. Hydraulic gradients will be confirmed through periodic water level measurements and hydrogeologic evaluations of the water level data. A Performance Monitoring Plan will be developed and approved by EPA in consultation with PADEP. The information generated by work performed under the Performance Monitoring Plan will be evaluated. Based on these evaluations, the extraction well system will be modified as necessary during the remediation period to optimize aquifer restoration and containment of DNAPL contaminants.

The beneficial use of the aquifer will be restored in part by pumping groundwater to achieve and maintain an inward and upward hydraulic gradient about WTMA 26. Hydraulic gradients will be confirmed through periodic

water level measurements and hydrogeologic evaluations of the water level data. The Performance Monitoring Plan will include adequate monitoring locations and frequencies to address this component. The Navy will assure that WTMA 26 continues to pump at pumping rates specified in a 1997 agreement between the U.S. and Warminster Township.

Components 2 and 3:

Extracted groundwater will be treated using the existing groundwater treatment system to meet effluent limits developed in accordance with National Pollution Discharge Elimination System (NPDES) requirements under Federal Clean Water Act, NPDES requirements under Pennsylvania Clean Stream Law (25 PA Code, Chapter 92) and Pennsylvania Wastewater Treatment Requirements (25 PA Code, Chapter 95) which currently exist for the discharge from the Groundwater Treatment System.

Volatile organic compound emissions from the air stripper in the existing treatment system will be treated by vapor-phase carbon adsorption to meet the standards established by 25 PA Code, Chapter 127, Subchapter, A, as well as the National Ambient Air Quality Standards for Hazardous Air Pollutants (NAAQS) under the Federal Clean Air Act. EPA Directive 9355.0-28, which covers emissions from air strippers at CERCLA sites, is a standard to be considered.

Spent carbon from the carbon adsorption units and sludge generated during treatment will be handled in accordance with treatment, storage and disposal requirements under RCRA Land Disposal Restrictions in 40 CFR Parts 262 and 268, Pennsylvania Hazardous Waste Management Regulations (25 PA Code Article VII) and Residual Waste Regulations (25 PA Code Article IX).

Component 4:

Institutional controls shall be implemented to prevent use of Area A groundwater as long as it presents an unacceptable risk and to protect the integrity and effectiveness of the extraction well network. These institutional controls can be divided into two categories; those that address current Navy property and those on current private property.

The institutional controls addressing Navy property will consist of restrictions on the future installation of wells and/or the use of water from wells installed in the future. Supply wells shall not be installed, and groundwater otherwise will not be withdrawn without the approval of the Navy and/or the EPA. These restrictions will be included in leases for affected property and deeds entered into for the transfer of such property. The implementation of these restrictions is administratively possible through legal actions to be taken by the Navy. The need for such restrictions shall be identified in Findings of Suitability to Lease and Findings of Suitability to Transfer, respectively, issued by the Navy.

The institutional controls for affected current private property within Warminster Township will consist of the continued enforcement by the Township of Warminster of its Ordinance No.32, which regulates well drilling in Warminster Township. The Navy will provide copies of performance monitoring reports (see Performance Criteria for Components 1 and 5) for consideration by the Township in enforcing this Ordinance. These reports will provide the location of extraction and monitoring wells and operational information including ground water elevation measurements. Analytical data will be provided to demonstrate contaminant trends with time both in the area of extraction well hydraulic contaminant and the downgradient area associated with the capture of contaminants by WTMA 26. Institutional controls for affected private property within Ivyland Borough will consist of enforcement of a well drilling regulation ordinance to be promulgated by Ivyland Borough.

Institutional controls must remain in place so long as a threat to human health and the environment is posed by Area A groundwater.

D. Summary of Estimated Remedy Costs

The estimated costs ($5,044,393) associated with the selected remedy are presented in Table 15. These costs consist of an estimated $7,688 for capital costs and $362,540 for O&M and $30,000 to $40,000 for monitoring costs per year over a 30-year period. The information presented on Table 15 is based on the best available information regarding the anticipated scope of the remedy. Changes in the cost elements are likely to occur as a result of information collected during the performance of the remedy. Revisions to the costs may be documented in the form of a memorandum in the Administrative Record file, an ESD, or a ROD amendment depending on the magnitude of the revisions. This cost estimate is an order-of-magnitude engineering estimate that is expected to be within +50 to –30 percent of actual project costs.

E. Expected Outcome of the Selected Remedy

The expected outcome of implementing the selected remedy in terms of land and resource uses and risk reduction are as follows:

- The DNAPL will be contained within the TI Zone.

- Area A groundwater outside of the TI Zone will be restored to remedial action levels and beneficial use.

- Use of the Area A groundwater will be restricted as long as it presents an unacceptable risk to human health.

Contaminants of concern (COCs) in Area A groundwater present an unacceptable human health risk.

The COCs in Area A groundwater and the remedial action levels for these COCs are as follows: TCE – 5 ug/l; PCE – 5ug/l; CCI_4 – 5 ug/l; 1,1-DCE - 7 ug/l; vinyl chloride – 2 ug/l; cis-1,2-DCE – 70 ug/l; 1,1,2-TCA – 5 ug/l; chloroform – 80 ug/l; and benzene – 5 ug/l.

In accordance with CERCLA Section 121(d)(4)(C) and Section 300.430(f)(1)(ii)(C)(3) of the NCP, the remedial action cleanup levels for TCE, PCE, and CCL_4 within the TI Zone are waived.

XIII STATUTORY DETERMINATIONS

Remedial actions must meet the statutory requirements of Section 121 of CERCLA, 42 U.S.C. 9621 as discussed below. Remedial actions undertaken at NPL sites must be protective of human health and the environment comply with ARARs of both Federal and state laws and regulations, be cost-effective, and utilize, to the maximum extent practicable, permanent solutions and alternative treatment or resource recovery technologies. Also, remedial alternatives that permanently and significantly reduce the volume, toxicity, and/or mobility of hazardous waste as the principal element are preferred. The following discussion summarizes the statutory requirements that are met by the selected remedy.

A. Protection of Human Health and the Environment

The selected remedy will be protective of human health and the environment through both containment and treatment components which decrease contaminant concentrations to levels protective of human health where practicable. Source area DNAPL concentrations of contaminants will be contained and migration of those contaminants will be controlled. The containment of this source area will cut off and isolate the source of contamination from downgradient portions of the aquifer. In addition, Area A groundwater contaminated with dissolved contamination attributable to Area A will be restored to remedial action levels protective of beneficial use and the unacceptable risk to human health will be eliminated.

Institutional controls will prohibit the use of Area A groundwater as long as the contaminated groundwater presents an unacceptable risk. Groundwater monitoring will assess the progress and effectiveness of the selected remedy.

There are no short-term threats that will exist that cannot be readily controlled.

B. Compliance with ARARs

The selected remedy will comply with all pertinent ARARs, including the remedial action cleanup levels for restoring Area A-related contaminated groundwater to drinking water standards (MCLs) to the extent practicable.

Groundwater data collected during the installation and operation of monitoring and extraction wells has identified the presence of DNAPL within Area A. Potential remedial technologies were evaluated in terms of their ability to cleanup the DNAPL zone. The results of this evaluation determined that extraction wells were found to be effective in restricting the migration of the dissolved contaminant plume in the immediate vicinity of the DNAPL zone but would not be effective in the complete capture and removal of the DNAPL. The evaluation also determined that other technologies would not be technically practicable to implement in the Area A DNAPL zone due to the depth of the DNAPL and the presence of fractured bedrock. The time required for complete dissolution of the DNAPL and subsequent restoration of the groundwater utilizing a groundwater pump and treat system was estimated to be in excess of 200 years.

In light of the estimated time for site cleanup and technical constraints regarding the ability to remove or otherwise cleanup the DNAPL at the site, and in accordance with CERCLA Section 121(d)(4)(C) and Section 300.430(f)(1)(ii)(C)(3) of the NCP, the Navy and EPA have determined that it is technically impracticable to achieve compliance with the following chemical-specific applicable requirements as they apply to the DNAPL within the TI Zone:

> Trichloroethene (TCE) - MCL [Safe Drinking Water Act, National Primary Drinking Water Standard MCLs, 40 CFR Part 141].
> Tetrachloroethene (PCE) - MCL [Safe Drinking Water Act, National Primary Drinking Water Standard MCLs, 40 CFR Part 141].
> Carbon Tetrachloride (CCl_4) - MCL [Safe Drinking Water Act, National Primary Drinking Water Standard MCLs, 40 CFR Part 141].

The Commonwealth of Pennsylvania, as represented by the Pennsylvania Department of Environmental Protection (PADEP), concurs with this action and as such the chemical-specific requirements for these contaminants as addressed by PA Safe Drinking Water Regulations, 25 PA Code, Chapter 109 are also waived for the DNAPL contained within the TI Zone.

The chemical-specific, location-specific, action-specific ARARs, as they apply to Area A groundwater, are as follows:

Chemical-Specific ARARs

Chemical-specific ARARs apply to two separate areas (dissolved plume and the TI Zone) for Area A groundwater and are as follows:

Dissolved Plume

Safe Drinking Water Act, National Primary Drinking Water Standard MCLs, 40 CFR Part 141]. PA Safe Drinking Water Regulations 25 PA Code, Chapter 109

The applicable chemical-specific ARAR concentrations in the dissolved aqueous Area A-related plume are TCE - 5 ug/l; PCE - 5ug/l; CCl_4 - 5 ug/l; 1,1-DCE - 7 ug/l; vinyl chloride - 2 ug/l; cis-1,2-DCE - 70 ug/l; 1,1,2-TCA - 5 ug/l; chloroform - 80 ug/I; and benzene - 5 ug/l.

TI Zone

In accordance with CERCLA Section 121(d)(4)(C) and Section 300.430(f)(1)(ii)(C)(3) of the NCP, the following chemical-specific applicable requirements are waived for the TI Zone [as depicted in Figure 18 and described in Appendix E of the final RI/FS for Area A Groundwater (TtNUS, 2000)]:

Trichloroethene (TCE) - MCL [Safe Drinking Water Act, National Primary Drinking Water Standard MCLs, 40 CFR Part 141].
Tetrachloroethene (PCE) - MCL [Safe Drinking Water Act, National Primary Drinking Water Standard MCLs, 40 CFR Part 141].
Carbon Tetrachloride (CC14) - MCL [Safe Drinking Water Act, National Primary Drinking Water Standard MCLs, 40 CFR Part 141].

All other chemical-specific requirements established for the dissolved plume apply to both the dissolved plume and the TI Zone. The waiver applies only to these compounds as they are present In DNAPL form within the TI Zone. Chemical-specific requirements for other site-related contaminants present in the groundwater both within and outside of the TI Zone, and for dissolved, site-related DNAPL chemical concentrations present outside the TI Zone are not waived.

The Commonwealth of Pennsylvania, as represented by the Pennsylvania Department of Environmental Protection (PADEP), concurs with this action and as such the chemical-specific requirements for these contaminants as addressed by PA Safe Drinking Water Regulations 25 PA Code, Chapter 109 are also waived for the DNAPL contained within the TI Zone.

Location-Specific ARARs

The substantive requirements of the Delaware River Basin Commission (18 C.F.R. Part 430) are applicable. These regulations establish notification requirements for the extraction and discharge of groundwater within the Delaware River Basin. However, no modifications to the selected remedy are expected due to the extraction and discharge called for in the remedy.

Action-Specific ARARs

Regulations concerning well drilling and well abandonment as set forth in 25 Pa. Code Chapter 107 are applicable. These regulations are established pursuant to Act 610 under the Pennsylvania Water Well Drillers License Act of 1956, 32 P.S.§ 645.1 et seq. Only substantive requirements of these regulations need be followed for on-site actions.

The groundwater collection and treatment operations will constitute treatment of hazardous waste (i.e., the groundwater containing hazardous waste), and will result in the generation of hazardous wastes derived from the treatment of the contaminated groundwater (i.e., spent carbon from carbon adsorption treatment of vapors and sludge generated during treatment). The remedy will be implemented in a manner consistent with the requirements of 25 Pa. Code Chapter 262, Subparts A (relating to hazardous waste determination and identification numbers), B (relating to manifesting requirements for off-site shipments of spent carbon or other hazardous wastes), and C (relating to pre-transport requirements); 25 Pa. Code Chapter 263 (relating to transporters of hazardous wastes); and with respect to the operations at the Site generally, with the substantive requirements of 25 Pa. Code Chapter 264, Subparts B-D, I (in the event that hazardous waste generated as part of the remedy is managed in containers) and 25 Pa. Code, Subpart J (in the event that hazardous waste is managed, treated, or stored in tanks). The remedy will also be implemented in a manner consistent with 40 C.F.R. Part 268, Subpart C, Section 268.30 and Subpart E (regarding prohibitions on land disposal and prohibitions on storage of hazardous waste).

25 Pa. Code Chapter 264, Subchapter F, regarding groundwater monitoring is applicable to the selected remedy.

Any surface water discharge of treated effluent will comply with the substantive requirements of Section 402 of the Clean Water Act, 33 U.S.C. § 1342, and the National Pollutant Discharge Elimination System (NPDES) discharge regulations set forth at 40 C.F.R. Parts 122-124, the Pennsylvania NPDES regulations (25 PA Code, Section 92.31), and the Pennsylvania Water Quality Standards (25 PA Code, Sections 93.1-93.9 which are applicable to the selected remedy.

25 PA Code Sections 261.24 and 273.421 are applicable regulations for the handling of residual and other waste and for the determination of hazardous waste by the Toxic Characteristic Leaching Procedure (“TCLP”).

The "off-site policy” (40 CFR 300.440), which prohibits the disposal of Superfund Site waste at a facility not in compliance with RCRA and all applicable State requirements, is applicable to the selected remedy.

Federal Clean Air Act requirements, 42 U.S.C. §§7401 et seg., are applicable and must be met for the discharge of contaminants to the air. The Pennsylvania Air Pollution Control Act is also applicable, as are Pennsylvania's Air Pollution Control Regulations, 25 PA Code, Chapters 121-142.

The requirements of Subpart AA (Air Emissions Standards for Process Vents) of the Federal Resource Conservation and Recovery Act (RCRA) regulations set forth at 40 C.F.R. Part 264 are relevant and appropriate and, depending upon the levels of organics in the extracted groundwater and treatment residuals, may be applicable to the air stripping operations conducted as part of the selected remedy. These regulations require that total organic emissions from the air stripping process vents must be less than 1.4 kg/hr (3 lb/hr) and 2800 kg/yr (3.1 tons/yr).

25 PA Code, Section 123.31 is applicable to the selected remedy and prohibits malodors detectable beyond the NAWC property line.

25 PA Code, Section 127.12(a)(5) will apply if new point source air emissions result from implementation of the selected remedy. These Commonwealth of Pennsylvania regulations require that emissions be reduced to the minimum obtainable levels through the use of best available technologies (BAT) as defined in 25 PA Code, Section 121.1.

The substantive requirements of 25 PA Code, Section 127.11 will apply to the selected remedy if additional air stripping units are required. These Commonwealth of Pennsylvania regulations require a plan for approval for most air stripping and soil venting/decontamination projects designed to remove volatile contaminants from soil, water, and other materials.

Standards to be Considered

EPA's Groundwater Protection Strategy, dated July 1991, seeks to protect groundwater for its highest present or potential beneficial use. The strategy designates three categories of groundwater for protection. Area A groundwater is designated as a Class II aquifer (i.e., groundwater that is currently used or potentially available).

Pennsylvania's Groundwater Quality Protection Strategy, dated February 1992 also seeks to protect groundwater for its highest present or potential beneficial use.

The U.S. EPA "Guidance for Evaluating the Technical Impracticability of Ground-Water Restoration"; Interim Final, OSWER Directive 9234.2-25, September 1993, was considered in evaluating site data and in developing remedial strategies. This guidance should be considered during the operation of the remedy.

C. Cost-Effectiveness

The selected remedy is cost effective because it provides overall effectiveness proportional to the cost. The selected remedy is the most readily implemented alternative that complies with all requirements.

D. Utilization of Permanent Solutions and Alternative Treatment Technologies or Resource Recovery Technologies to the Maximum Extent Practicable

The selected remedy provides long-term effectiveness and uses a permanent solution to the maximum extent practicable that effectively controls and eliminates the risks associated with OU-1A. Alternative treatment technologies and/or resource recovery technologies were found to not be appropriate for the site conditions or planned reuse.

E. Preference for Treatment as a Principal Element

The selected remedy, to the extent practicable, achieves the preference for treatment as a principal element. Contaminants of concern in Area A groundwater will be removed and permanently destroyed through treatment. That portion of Area A-related groundwater contamination that consists of DNAPL, located within the TI Zone, will be contained and that portion that is captured by the hydraulic containment extraction wells will be removed from the groundwater and permanently destroyed through treatment.

F. Five-Year Review Requirements

Because contamination remains in the groundwater at levels above the MCL and the time required to capture and remove those contaminants to acceptable levels is undefined, a five-year review will be required for this remedial action.

G. Documentation of Significant Changes

The selected remedy is the same alternative identified as the recommended alternative in the Proposed Plan and that was presented to the public at the public meeting held July 19, 2000.

No significant changes were made to the recommended remedial action alternative in the Proposed Plan.

XIV. RESPONSIVENESS SUMMARY

A. Background on Community Involvement

The Navy and NAWC Warminster have had a comprehensive public involvement program for the last ten years. The Navy organized a Technical Review Committee (TRC) in January 1989 to review and discuss NAWC CERCLA issues with local community officials and concerned citizens. The TRC was reorganized into the Restoration Advisory Board (RAB) in November 1993. The RAB consists of representatives of the Navy, EPA, PADEP, the Bucks County Health Department, the Northampton Township Municipal Authority, the Warminster Township Municipal Authority, Ivyland Borough, and Upper Southampton Township, as well as members of the community and concerned environmental organizations. In 1994, NAWC Warminster prepared a Community Relations Plan for environmental activities at the base. Community relations activities have been conducted in accordance with this plan. These activities have included regular technical and restoration activity meetings with local officials, communications with the media and the establishment of information repositories. The RAB and a technical subcommittee (TSC), consisting of representatives from the RAB, have met on a regular monthly basis since its formation. The RAB has been assisting in the planning and review of environmental investigation, remedial alternative evaluation, and remediation activities, along with future land use planning.

RAB meeting minutes along with reports presenting the results and findings of investigations are maintained in two local information repositories that contain the Administrative Record for NAWC Warminster. One repository is located at the base; Navy Caretaker Site Office located at 860 Flamingo Alley Warminster, Pennsylvania; and the other is located in a local library; Bucks County Library located at 150 South Pine Street, Doylestown, Pennsylvania.

Community relations activities for the final selected remedy include the items below:

- The documents concerning the investigation and analysis at OU-1A were presented in RAB and TSC meetings and draft and final copies were provided to all RAB members for review, discussion, and comment.

- The documents concerning the investigations and analysis at OU-1A, as well as a copy of the Proposed

Plan, were placed in the information repositories.

- The Navy mailed copies of the Proposed Plan to about 450 local area residents whose names appeared on the RAB mailing list.

- Newspaper announcements on the availability of documents and the public meeting and comment period were published in the *Bucks County Courier Times, Philadelphia Inquirer,* and *Intelligencer.*

- The Navy established a 30-day public comment period starting July 10, 2000 and ending August 9, 2000.

A Public Meeting was held on July 19, 2000 to present the Proposed Plan and to answer questions concerning OU-1A.

B. Summary of Comments and Responses

The local community and representatives of local municipalities expressed concern regarding the preferred alternative (Alternative 2) presented in the Proposed Plan. Written comments were submitted on behalf of Warminster Township, Warminster Township Municipal Authority, and Ivyland Borough (Appendix C). These comments and responses to these comments are provided below. The Navy and EPA have taken these concerns into consideration and believe that Alternative 2 adequately and appropriately addresses the contamination associated with Area A groundwater in a cost effective and responsible manner.

<u>EARTH DATA COMMENTS – AUGUST 8, 2000</u>

Comment 1: WTMA does not concur with the Navy's interpretation of the characteristics of the Stockton Foundation underlying Area A. The Navy's interpretation purports that there are uniform, laterally extensive mudstone units underlying Area A, which are unique to Area A, which act as barriers to vertical groundwater flow and the downward migration of contaminants.

WTMA does not believe that the data presented in the RI conclusively identifies these units. Further, the importance of these units is overemphasized. As described in the RI, these low permeability units most closely match the description of an aquitard. The RI acknowledges the presence of dense, non-aqueous phase liquids (DNAPLs) in Area A. Current scientific research conducted at DNAPL sites worldwide shows that many (if not most) silty or clayey aquitards commonly contain fractures or other openings which allow DNAPLs to move through them, thereby causing contamination of underlying aquifers.

Response 1: Based on the Navy's work at the base, on U.S. Geological Survey (USGS) experience with the Stockton Formation, and on published reports, mudstone units can be locally extensive in the site area. Based on a combination of boring and geophysical logs, water level data, aquifer testing results (note depth-specific recoveries during WTMA 26 water level study), and contaminant data, the Navy feels that the interpretations provided in the report are reasonable representations of site conditions to the level of detail required to adequately characterize the site.

The RI/FS report for Area A groundwater states that hydrogeologic interpretations are based on a number of factors, including, but not limited to, borehole geophysical logs. The Navy has made no attempt to minimize the role that subsurface structure and fracturing plays in groundwater and contaminant occurrence and distribution. Throughout the hydrogeologic discussions, fractures are presented as the primary groundwater flow paths, and the interpretations of hydrogeologic units rely on bedrock structure to a great degree. The minimal amount of contamination detected in hydrogeologic unit C wells, even those installed within the source area, indicates that the mudstone unit which forms the base of hydrogeologic unit B functions as an effective aquitard and prevents DNAPL from migrating vertically downward,

Comment 2: The RI presents 1997 groundwater sampling data which shows that four of six wells sampled from Hydrogeologic Unit C contained trichloroethene (TCE) which exists as a DNAPL in Area A. This sampling event preceded the installation of the on-base extraction wells that occurred in the December 1998-March 1999 time frame. The RI also presents the results of the June 1999 groundwater monitoring which was performed to establish baseline groundwater quality conditions within Area A prior to the startup of the extraction wells. No wells from Hydrogeologic Unit C were sampled and no explanation is provided. This circumstance raises additional questions regarding the Navy's interpretation given that unsealed or improperly sealed boreholes are common vertical pathways for DNAPLs.

Response 2: The sampling and analysis plan addressing the June 1999 monitoring event did not include the sampling of wells from Hydrogeologic Unit C. Previous groundwater investigations for Area A revealed that the VOC levels in Hydrogeologic Unit C wells (i.e., HN-11D, HN-12D, HN-13D, HN-15D, HN-16D, and HN-50D) were relatively low and that contaminants were infrequently detected. In the most recent comprehensive round of Area A groundwater sampling (December 1997), TCE concentrations in the wells that are installed below hydrogeologic unit B were all lower than the MCL of 5 ug/I. Baseline groundwater quality conditions were documented in the Summary Report for Area A and Area D Groundwater Monitoring (Brown & Root Environmental, February 1998). Based on these results, the June 1999 monitoring event specifically focused on shallow- and intermediate-depth wells corresponding to Hydrogeologic Units A and B. This general lack of significant contamination confirms the Navy's interpretation that the mudstone is an effective barrier to vertical migration of DNAPL and this, along with the significant hydraulic head differentials typically seen between wells installed in adjacent flow zones, indicates that the wells installed are effectively sealed to

prevent vertical migration along the borehole. The long term performance monitoring plan for OU-1A will include monitoring of hydrogelogic unit C to ensure that the remedial action is protective of deeper groundwater.

Comment 3: The RI/FS states that contamination patterns off base and downgradient of Area A indicate the presence of other sources of contamination not related to NAWC Warminster. This is not a new theory. In fact, the Navy first put forth this hypothesis in 1984. For the record, for some time now, EPA has been performing its independent assessment of potential off-base source areas. Further, the data in the RI/FS raise questions about the Navy's hypothesis.

Response 3: The data in the RI strongly supports the hypothesis of offbase sources of contamination. This view is shared by the U.S. EPA and USGS. For more information regarding data supporting the hypothesis of the existence of offbase sources, refer to Responses 4 and 5.

Comment 4: The statement in the RI/FS referring to the absence of PCE and 1,1,1-TCA in Area A is misleading. One of the principal findings of sampling performed in 1980 by SMC Martin was the detection of PCE, TCE, and 1,1,1-TCA in two monitoring wells SMC-1 and SMC-2 installed at the site of the Navy's old sludge lagoons. Additional information about the detection of PCE and 1,1,1-TCA in Area A is provided in the Stages I and II RI Report prepared by SMC Environmental Services Group in April 1991. One of the conclusions of this report was that TCE, PCE, chloroform, carbon tetrachloride, and 1,1,1-TCA originate from on-base sources of contamination.

Response 4: The RI/FS report for Area A groundwater indicates that TCE, PCE, chloroform, carbon tetrachloride, and 1,1,1-TCA were contained in Area A well samples. The SMC report conclusion that the contaminants **detected in on-base wells** originate from on-base sources is not an issue nor is it in conflict with the RI/FS report for Area A groundwater.

Comment 5: The conclusion that the contamination in HN-52 originates from an off-base source is inconsistent with the following interpretation taken from the Navy's *Draft Area A/Off-Base Water Level Study*: "The groundwater flow maps do not show groundwater migrating directly from the on-base area of greatest groundwater impacts (Site 1 located in the HN-11 area) to WTMA Well 26 under pumping and non pumping conditions encountered. From the area groundwater appears to migrate towards cluster HN-52. Given the pronounced strike parallel drawdown pattern observed in the aquifer through comparison of water levels obtained during pumping and non pumping conditions (Figure 3-2), however, the water level data indicate that an extended capture zone exists for WTMA Well 26 along strike of the geologic units and is probably large enough to capture groundwater migrating through the *HN-52/HN-65* areas." WTMA believes that most of

contamination in well HN-52 originates in Area A. The technical data regarding possible off-base contributors are insufficient to support the Navy's theory.

Response 5: There is no well "HN-52". There is a **cluster** of wells designated as HN-52S, 52I, 52D, and 52DD, each screened across a different depth interval at cluster location 52. To properly understand the issue and the Navy's interpretation regarding the presence of an off-base source, the pattern of contamination with depth must be considered. As described in detail in the RI Report, the pattern of groundwater contamination is much different in well HN-52S than in the deeper wells at this cluster location, and also substantially different from the onbase pattern of contamination. The different chemical signature is most evident in regards to the relatively high concentrations of 1,1,1-TCA, 1,1-DCE, 1,1-DCA, and PCE found in HN-52S relative to other wells at this location and wells located within and immediately downgradient of Area A. The RI conclusions in regards to well HN-52S are not inconsistent with the results of the Area A/Off-Base Water Level Study, as both reports indicate that the contamination found in well HN-52S does not appear to be Navy-related. There are ample potential sources between Area A and well HN-52S to account for the contamination seen in well HN-52S, based both on location and the interpretations of groundwater flow patterns indicated in the RI/FS report for Area A groundwater and elsewhere. The differing chemical fingerprint of this well in comparison to both nearby wells and other wells at this cluster location, along with the magnitudes of the concentrations of the chemicals found in comparison to contaminant levels and distributions nearby (including Area A), indicate that an off-base, non-Navy source exists and is impacting groundwater.

The interpretation that off-base sources contribute contamination to well HN-52S has adequate technical backup at this time. The Navy feels that it has an obligation to the public to point out the likely presence of other groundwater contaminant sources for potential future public health reasons.

Comment 6: WTMA questions the technical basis to support the conclusion that groundwater pump and treat will eventually remediate contaminated groundwater downgradient of the TI zone, to comply with chemical specific ARARs such as MCLs. Historically, pump and treat has had very limited success in restoring fractured media contaminated with DNAPL compounds to health based levels, which is the documented condition in Area A.

Response 6: The RI/FS report for Area A groundwater does not state that the aquifer in the DNAPL area will be remediated to cleanup goals. A Technical Impracticability (TI) waiver has been prepared specifically because the Navy believes that this area will remain contaminated for the foreseeable future. Once the source of contamination (DNAPL zone) is hydraulically contained, the source of downgradient groundwater contamination (at least the Navy source) will be isolated and cleanup will consist of the removal of residual dissolved concentrations. Ultimately, the time frame required for this cleanup and the long term effectiveness

of the remediation system for downgradient groundwater will be determined by actual long term sampling data, not by any projections.

Comment 7: Groundwater contamination was first detected at NAWC Warminster in 1979. In its May 1992 memorandum entitled *Considerations in Groundwater Remediation at Superfund Sites and RCRA Facilities,* EPA recommended early action to prevent or minimize the further migration of contaminants particularly in situations involving DNAPL. Despite this, it still took the Navy an additional seven years to implement the interim groundwater remedy.'As a result, contamination attributable to the Navy migrated off base. WTMA believes that there is insufficient monitoring data to demonstrate that the interim system, which has been in more or less continuous operation for about one year, creates a capture zone that encompasses the on base portion of the plume. Further, WTMA believes that additional monitoring data (both on base and off base) is needed to adequately support an operating properly and successfully (OPS) demonstration.

Response 7: The presence of DNAPL within Area A was not known at the time that the interim remedy ROD was signed. When data were collected suggesting the presence of DNAPL, a cautious approach to further delineation and eventual remedial actions was taken, in large part to ensure protection of WTMA 26. These actions included upgrading the treatment system for WTMA 26, which was not called for in the interim remedy ROD but done by the Navy as part of an overall course of action that was prudent and responsible. In addition, the groundwater response was delayed in order to address Area A soils, which were considered a potential source for the groundwater contamination. The effectiveness of the on-base groundwater extraction system in containing source area groundwater contamination will be evaluated through performance monitoring activities and appropriate revisions made to the system in consultation with EPA.

An OPS demonstration is required as a precondition to the deed transfer of federally-owned property. The demonstration must show that the remedy was constructed in accordance with an approved design and is operating properly. It must also show that the continued operation will eventually achieve the cleanup levels, and that it is protective of human health and the environment, which the EPA interprets as the remedy is functioning in such a manner that it is expected to adequately protect human health and the environment when completed. The data collected to date indicate that the remedy currently operating meets these requirements for the selected remedy.

Comment 8: WTMA objects to the Navy's selection of Alternative 2 over Alternative 3 as the preferred alternative on the basis that Alternative 3 would be "far more difficult to implement". In WTMA's view, the Navy's preference appears to be based solely on the Navy's position that it need not address aggressively the plume(s) or contaminated groundwater attributable to the Navy which extend downgradient of the capture zone and which are captured and treated by WTMA 26, because of the possibility that other off-site sources may thereafter commingle with the Navy's plume. In WTMA's opinion, there is no legal basis or justification

for such a position in CERCLA despite the Navy's claim to the contrary that federal facilities as polluters are not under the same obligation as are private parties insofar as commingled plumes of contamination are concerned. The Navy's remedial plans should not assume that the Navy's obligation to aggressively remediate off-base contamination can be allocated on a molecule by molecule basis. Not only is such an approach technically unsound, but it is bad public policy, particularly where as here. the offsite recipient of the plume is a public water supply well. At this point, the technical data regarding possible off-site contributors is simply insufficient to support the Navy's commingling theory, at least insofar as contributions to WTMA 26 are concerned. The fact that the Navy may have a contribution action against any third parties ultimately found responsible for some of the contamination does not, and should not influence the selection of the best or most protective remedial approach when a public's water supply is at stake. The Navy must take a more aggressive position on its remediation, regardless of how a court ultimately may decide to allocate shares of the remedial cost.

Response 8: The Navy has not delayed nor has it restricted the scope of remedial efforts to address the Navy-related contamination as a result of the presence of other sources of groundwater contamination. Federal facilities, as lead agencies, are limited by Executive Order 12580 in the exercise of CERCLA authorities and the expenditure of Defense Environmental Restoration Account funds in addressing comingled plumes. As the lead agency implementing CERCLA at the Area A groundwater site, the cleanup of the portion of the contamination that is not attributable to the Navy is beyond the Navy's delegated authority, as is the investigation of other sources. It is the Navy's obligation, however, to clean up all Navy-related contamination.

No assumption has been made by the Navy in its remedial planning that contamination can be allocated on a molecule by molecule basis, nor has any potential future legal action in regards to any potential third parties entered into any of the decisions regarding the selection of the most appropriate remedy for the site.

Comment 9: It is technically unsound, legally inadequate, and inconsistent with the NCP, to espouse or imply in the RI/FS, or the Proposed Plan that less rigorous investigation or remediation of off-site components of the Navy's plume, by the Navy, is appropriate because of the potential that other off-site sources may be contributing to, and commingling with hazardous substances released by the Navy. If offsite plume concentrations attributable to the Navy warrant remedial action (and they do), then remedial action should be taken now, by the Navy. It should not be put off to some unspecified future date when, presumably, someone will have more data on which TCE molecules originated on the Base and which originated somewhere else. In the absence of remedial action, the Navy is, in effect and through a refusal to act, determining that the public health and environmental risks of plume migration are inconsequential, a public decision that is without support in the empirical data.

Response 9: Remedial actions have been undertaken by the Navy, both to remove soils which could

potentially impact groundwater and to install a groundwater extraction and treatment system which is currently operating and has been for approximately one year. In addition, the Navy upgraded the pre-existing treatment system for WTMA 26, and pays for the operation and maintenance of the treatment system. See the response to Comment No. 8 for additional information in response to this comment.

Comment 10: WTMA believes it is inappropriate to formally "select" as a CERCLA remedy use of WTMA 26 as a plume containment/remediation system for the release or threatened release of hazardous substances from NAWC Warminster.

Although it has been recognized that Well 26, an active municipal supply well, is impacted by the release of hazardous substances from NAWC Warminster, and the Authority runs a treatment system on the well to protect health and safety, its operation of Well 26 should not be co-opted through federal action as a remedial system operated for the benefit of the United States. Any benefit the United States obtains through the Authority's operation of Well 26 is purely incidental to the Authority's pre-existing operation of Well 26 for public water supply purposes. The Authority is very concerned that the public, among others, will wrongly perceive such a declaration in the PRAP and ROD as a determination that the Authority or the United States are remediating contamination migrating from NAWC-Warminster by delivering it to the public through the operation of the water supply system. At most, the PRAP and ROD should recognize that plume migration from the areas in question is not being addressed because existing systems provide the incidental benefit of containing plume migration. The ROD could state, for example, that should the Authority discontinue operation of Well 26 for public water supply purposes, a determination would need to be made regarding the use of that well or a different withdrawal well to enhance the Navy's capture or containment of contaminants that may have migrated from the base. But formal statements indicating that operation of Well 26 is part of the formal selected remedy and one component of the remediation system designed for the Base are inappropriate and ill-advised. The ROD also should document the fact that the United States will continue to work with the Authority to monitor Well 26 to be sure that water being extracted at that point does not pose any unreasonable risk to public health and safety.

Response 10: Regarding the use of WTMA 26 as part of the remediation system, the settlement agreement signed between the United States (on behalf of the Navy) and WTMA formally recognizes that the operation of the well is of benefit in capturing contamination in area groundwater, that the United States (on behalf of the Navy) desires to see WTMA 26 continue in operation so as to continue to capture contaminated groundwater, and requires that WTMA make its best efforts to continue operation of the well at its target rate. Furthermore, the agreement requires that WTMA provide 9 months notice prior to ceasing operation of the well, during which time, if the United States judges that continued operation of the well is desirable, the two parties must meet and in good faith negotiate an arrangement for continuing the operation of the well. The settlement agreement thus implicitly ties in WTMA 26 as a component of the overall remedial strategy, and

to ignore its role in remediating groundwater associated with the site would artificially limit the scope of remediation proposed by the Navy. Regarding the suggested PRAP/ROD language on determinations to be made should WTMA decide to discontinue use of the well, if and when WTMA notifies the United States of this intent, the Navy and EPA will reevaluate the effectiveness and protectiveness of the remedy.

PENNONI COMMENTS - AUGUST 9, 2000

Comment 11: The PRAP is based on the hydrogeologic interpretation that describes Hydrogeologic Units A, B, and C as extending across Area A and continuing to WTMA 26. We concur that the zones may represent primary zones of groundwater movement and aid in interpretation of the movement of groundwater. However, we believe that the confining layers between these areas should not be assumed to be continuous. It is likely that fractures or other discontinuities provide local pathway for migration of water and contamination between units which may not be reflected in the measured head differential between wells screened in the different intervals. This possibility needs to be considered in the evaluation of the performance or the selected remedy.

Response 11: Based on the Navy's work at the base, on USGS experience with the Stockton Formation, and on published reports, mudstone units can be locally extensive in the site area. Based on a combination of boring and geophysical logs, water level data, aquifer testing results (note depth-specific recoveries during WTMA 26 water level study), and contaminant data, the Navy feels that the interpretations provided in the report are reasonable representations of site conditions to the level of detail required to adequately characterize the site.

Comment 12: The Navy has issued an OPS determination for the existing groundwater treatment and extraction system before the public comment period or a Record or Decision was complete. This is premature from both a procedural and technical standpoint. From a procedural point of view it indicates that the Navy is already convinced that the remedy is adequate and sufficient without giving any consideration for the possibility that the public input may indicate otherwise. From a technical point of view the OPS determination is based upon less than one year of data which provides a very limited database for predicting long-term performance. For comparison, the OPS for the Area C groundwater extraction and treatment system was issued almost four years after implementation of the remedy.

Response 12: At the time the Proposed Remedial Acton Plan for Area A groundwater was released for public comment, a draft OPS determination document for Area A groundwater had also been prepared and released to NAWC Restoration Advisory Board members for comment. This draft OPS document assumed that the preferred alternative identified in the PRAP for Area A groundwater would be selected as the final remedy in the final ROD for Area A groundwater. If public comments or other considerations had led to the selection of

a different alternative as the final remedy, the OPS document would have needed to have been revised accordingly based on the implementation of the alternative remedy and collection of associated operating data. In any case, an OPS demonstration cannot be made prior to or without the identification of a final remedy in a final ROD. Accordingly, an OPS document for Area A groundwater has not been finalized.

Regarding the extent of operating data currently available for predicting long-term performance, an OPS determination requires that available data support the conclusion that the remedy is operating and is likely to be successful in achieving remedial action levels. Data generated to date suggest that the selected final remedy will eventually achieve remedial action levels outside of the TI Waiver zone. Five-year ROD reviews will be used to address the long-term performance of the system and identify whether the remedial approach should be modified.

Comment 13: The Navy states that some of the groundwater contamination is attributable to off-base sources. Since none of these alleged sources have been identified or delineated, we are concerned that portions of the contaminated plume which originated at the base will not be considered part of the remedy because of the Navy's belief that the plume is co-mingled (i.e., blended) or originated elsewhere. Presently, there is insufficient evidence to determine the nature of the alleged off-base sources and additional investigation and long-term monitoring will be required to define the plume.

Response 13: It is the Navy's intent to clean up all contaminated groundwater emanating from Area A, through hydraulic containment of the source area and downgradient plume capture by WTMA 26. Long term performance monitoring will be performed as part of the remedy. The investigation of offsite sources is not a Navy responsibility and is not planned by the Navy; such actions are beyond the scope of the Navy's delegated CERCLA authorities. The likely existence of offbase sources has been made known to the State and EPA.

Comment 14: Some of the contamination which the Navy attributes to a potential off-base source is in the vicinity of well HN-50S which is north of the Hobensack well in Ivyland. However, the Wagner well was pumping for many years with consistently elevated levels of TCE. Although the Wagner well is no longer pumping, the influence of the well in drawing a portion or the plume into Ivyland needs to be evaluated based on long term monitoring and the results in well HN-50S may reflect that effect.

Response 14: The Navy agrees that more data are needed to draw definite conclusions regarding whether the contamination in HN-50S is Navy-related. Future performance monitoring will provide data with which to further evaluate whether the source of the contamination in HN-50S is the Navy.

Comment 15: The. Proposed Plan and RI/FS report for Area A Groundwater do not address the risk to residents of Ivyland who are connected to public water but who still use their wells for filling their swimming pool or watering their lawn. These risks should be addressed in the selection of a remedy.

Response 15: The Navy has sampled 20 residential wells to date within Ivyland Borough to help assess the nature and extent of Area A groundwater contamination. The subject wells are all of the private wells known by the Navy to be in use at this time. The results of this monitoring provide no indication that Area A groundwater is present in any of these residential wells at levels that present an unacceptable risk. A level of 16 ug/l of PCE was detected in one residential well. However, available information suggests that Area A is not the source of this contamination. The Navy is currently unaware of any other specific wells within Ivyland which are used for either potable or non-potable purposes or any water quality data for such wells. The Navy plans to work with Ivyland Borough to identify any well use currently unknown to the Navy and to assess the risk associated with such use. If unacceptable risks are identified and determined, the Navy and EPA will evaluate the remedy selected by this ROD to determine what additional actions, if any, are required to protect human health and the environment. Future access to Area A groundwater which presents an unacceptable risk (i.e. future drilling of wells in the affected area) will be prohibited by institutional controls to be implemented as part of the final remedy. The Navy and EPA will evaluate any new data or information that becomes available through the monitoring of the selected remedy and/or through other sources.

Comment 16: The RI/FS report for Area A groundwater calculates a relatively short clean-up time (i.e., less than 11 years) for the portion of the contaminant plume outside the Technical Impracticability (TI) waiver zone where the Dense Non-Aqueous Phase liquid (DNAPL) is present. The clean-up time seems overly optimistic and a rate calculation using the May and June 2000 data for the downgradient wells indicates a longer time to remediate the groundwater to safe levels.

Response 16: Based on the data available, the approach taken to estimate clean-up times is reasonable. As more data become available, the clean-up rate projections can be refined. Using data collected from immediately prior to extraction system startup through May 2000, the predicted clean-up time is actually shorter than that provided in the RI/FS. Regardless of any calculated projections, the ultimate time required for cleanup will be dictated by actual sampling results over time, not by any projections made.

Comment 17: The Proposed Plan states that the contaminant plume downgradient of the capture zone of the extraction well network is captured and treated by WTMA 26. For the Navy to conclusively determine that VVTMA 26 is capturing all of the plume, monitoring wells need to be installed downgradient of WTMA 26 to the depth of concern and sampled on a regular basis.

Response 17: The Navy and EPA believe that WTMA 26 is effective in capturing the diffuse contaminant plume attributable to Area A. The groundwater results (if available) for any current or future wells downgradient of WTMA 26 would not be useful for determining attribution solely related to the Navy. In December 1997, the Navy sampled USGS Well BK-1059, which is located about 3,100 feet from the base property boundary and 1,400 feet north of WTMA 26. Very low VOC levels (i.e., less than 3 ug/l) were contained in the well sample, including TCE, PCE, 1,1-DCE, 1,1-DCA, and 1,1,1-TCA. WeII BK-1059 is an open WTMA borehole approximately 400 feet in depth and cased 66 feet below the ground surface. These results support the conclusion that significant VOC groundwater contamination does not exist downgradient of WTMA 26. It should also be noted that the sampling results from wells further away from the site are somewhat ambiguous in terms of their applicability to the site, due to the potential presence of other sources of groundwater contamination in addition to the former Navy property.

Comment 18: The Proposed Plan and the FS report for Area A groundwater describe an Alternative 3 that includes off-base extraction wells. The Navy has selected Alternative 2, which includes the existing extraction well network and well EW-18. We believe that the remediation of the off-base portion of the plume will take longer than the Navy projects. Because of the complex nature of fractured bedrock, there may be portions of the plume which will not be remediated in a timely manner through operation of the current system. Therefore, we believe that Alternative 3 be added to the ROD as a contingency remedy to be implemented in the event that future monitoring shows inadequate restoration of the groundwater aquifer.

Response 18: The selected remedy for Area A groundwater includes periodic groundwater monitoring to monitor the progress of the remedy and to ensure that groundwater contaminant migration is not occurring. The selected remedy also includes 5-year reviews to ensure that the remedy is, or will be, protective of human health and the environment. In the event that the monitoring results and the 5-year reviews indicate that the aquifer (outside of the TI Zone) cannot be adequately restored, the Navy and EPA will evaluate the selected remedy and propose any necessary modifications based on that assessment. A contingency remedy is therefore not needed at this time because the selected final remedy is a proven technology for containing groundwater contaminant plumes and is anticipated to eventually restore the aquifer to beneficial use. Since groundwater moves through the fractured rock aquifer relatively quickly at the site and the cleanup time is a function of the flushing rate of the aquifer, the incremental benefit to implementing Alternative 3 versus Alternative 2 in regards to ultimate cleanup time is minimal, if any. On the other hand, the implementation of Alternative 3 is much more likely to have a substantial negative impact on the water-producing capacity of WMA 26 than Alternative 2.

BOROUGH OF IVYLAND COMMENTS - AUGUST 9, 2000

Comment 19: What is the projected number of years respectively for the alternatives to restore Area A

groundwater outside of the TI zone to useable standards?

Response 19: For Alternatives 2, and 3, the Rl/FS report for Area A groundwater estimates a clean-up time of less than 11 years for the portion of the contaminant plume outside the TI zone.

Comment 20: What will be "useable standards"?

Response 20: Performance criteria, including useable standards, for restoring Area A groundwater are described in Section XV of the ROD. The useable standards are the Maximum Contaminant Levels (MCLs) (as promulgated by the Safe Drinking Water Act) for the contaminants of concern in Area A groundwater.

Comment 21: When extracting 600 pounds vs. 150 pounds of compounds per year, would this imply that “useable standards" could be achieved four times quicker?

Response 21: The initial removal rate of contaminants may be higher for Alternative 3, but the longer term removal rates are likely to be similar for both pump and treat alternatives. Over the long term, achieving useable standards is likely to require a similar timeframe for both Alternatives 2 and 3.

Comment 22: Because the Alternative 2 treatment has already begun, is the Capital Cost already included in the Alternative 2 30-year NPW? If so, what is the Capital Cost already included in the Alternative 2 30-year NPW? If not, what is the new anticipated Capital Cost included in the Alternative 2 30-year NPW and for what uses? What is the anticipated Capital Cost included in the Alternative 3 30-year NPW? What are the projected Operation and Maintenance Costs each year respectively for both alternatives?

Response 22: As detailed in Appendix F to the RI/FS report for Area A groundwater, the estimated capital cost for Alternative 2 is $8,000 to prepare deed restrictions for the final Area A groundwater remedy. The cost of constructing the groundwater treatment plant is not included in the Alternative 2 capital cost. The estimated Alternative 3 capital cost is $936,060, as Alternative 3 includes major modifications to the current groundwater treatment plant.

The estimated annual O&M cost for Alternative 2 is $476,700 for Years 1 through 6 and $364,700 for Years 7 through 30. The estimated annual O&M cost for Alternative 3 is $362,540 for Years 1 through 6 and $364,700 for Years 7 through 30.

Comment 23: Is the "potential for exposure" in evaluating Alternative 3 really a strong reason to be mentioned for consideration in evaluating the choice of alternatives? Is Alternative 3 going to expose construction workers to any greater potential levels of contamination than has been experienced throughout the NAWC

clean-up process?

Response 23: Short-term effectiveness is only one of several criteria that were required to be used to evaluate the remedial alternatives for addressing Area A groundwater. The primary (or threshold) criteria were overall protection of human health and the environment. Alternative 3 will not expose workers to any greater levels of contamination than have been experienced to date at the base as part of clean-up work.

Comment 24: Both Alternatives 2 and 3 intend "to limit exposure to contaminated groundwater" through institutional controls. In general, what are institutional controls? How are they instituted? Do they require legislative action by Ivyland Borough? How are they enforced? What are anticipated costs to implement institutional controls? Who pays for the costs? Specifically, what institutional controls are proposed for Ivyland Borough? Do they apply only to a portion of the Borough that is exposed to contamination above a certain level?

Response 24: Institutional controls consist of actions that are designed to restrict or limit certain activities, such as installation of wells and certain uses of groundwater. Institutional controls can be established and enforced through deed restrictions that are placed in the applicable deed for transferring property. Institutional controls can also be implemented and enforced through zoning or municipal ordinances.

The selected remedy in this case includes a municipal ordinance to be promulgated by Ivyland Borough. In selecting this remedy, the Navy plans to coordinate and work with Ivyland Borough as necessary to promulgate such an ordinance. The Navy has the ultimate responsibility for enforcement of all institutional controls. In the case of the municipal ordinance to be promulgated by Ivyland Borough, the Navy and Ivyland should come to a mutual agreement regarding the process for ensuring enforcement of the ordinance. If necessary, this agreement could include a provision for Navy review of technical documents which are generated in response to ordinance requirements. At this time, the Navy has assumed that no costs will be incurred in the promulgation and enforcement of this ordinance by either the Navy or Ivyland. The ordinance of concern should regulate the installation and operation of groundwater wells in that portion of Area A groundwater within Ivyland that presents an unacceptable risk or which could impact the integrity and/or effectiveness of the final Area A groundwater remedy. Based on available data, the area of interest should apply to those areas where pumping of groundwater would yield groundwater with contaminants of concern at levels above MCLs. In addition, the ordinance should prevent well drilling or the withdrawal of groundwater within Ivyland which would impact the effectiveness of the remedy for Area A groundwater. Both of the areas of interest would be identified by the Navy based on the latest available information. The Navy will continue to monitoring the Area A groundwater as part of the final remedy and will provide written reports of findings to the municipalities with the subject well regulation ordinances.

Comment 25: The mechanics of Alternative 2 are essentially in effect now by use of an extraction, treatment, discharge system. Where exactly is the unnamed tributary of Little Neshaminy Creek located? Where Is the point of discharge? How often is the treated discharge monitored for contamination? What are the acceptable levels of contamination to allow continued discharge?

Response 25: The unnamed tributary is located north of Bristol Road about 5,000 feet northwest of the on-base groundwater treatment system. The point of discharge (Outfall 001) is located at latitude 40 04' 28". Until recently, discharge quality limitations were imposed by the Pennsylvania Department of Environmental Protection (PADEP). Monthly sampling was performed on the treated and discharged groundwater. With PADEP concurrence, the Navy regularly samples the discharge to ensure that the treatment system is adequately removing contaminants from the treated water prior to discharge. Sampling data are provided to PADEP upon request. The discharge limits were described in the ROD for OU-1, dated September 1993.

Comment 26: The mechanics of Alternative 2 or 3 require components of the system to be located "off-base". We understand that a parcel of land in Ivyland Borough, immediately adjacent to the TI zone, has recently been purchased by the Navy. Also, several new monitoring and/or extraction wells and associated piping are now located in Ivyland Borough generally between the purchased property and the railroad tracks. Has the Navy placed any restrictions on, or requested any special uses to enable the Navy to access these "off-base" facilities located within neighboring municipalities? Should neighboring municipalities be officially notified in writing from the Navy about any restrictions or special uses on private property within the municipality?

Response 26: The Navy has several access agreements in place with nearby property owners to sample wells at off-base facilities. The Navy does not formally plan to notify neighboring municipalities about possible restrictions or special uses on private property. The ROD itself is a legal and public document which the Navy will send to these municipalities.

Comment 27: Private wells were the primary source of drinking water until the 1970s when municipal water became available in Ivyland Borough. Concerns of long-term health risks from possible exposure to contaminated groundwater from the 1940s through the 1970s have been raised by residents. What information is available regarding the kinds and levels of contamination in Ivyland Borough groundwater from the 1940s through the 1970s? What health risks are associated with consumption of well water under such circumstances?

Response 27: The Navy did not conduct or sponsor investigations regarding potential Ivyland Borough groundwater quality until the 1990s, and is unaware of any Navy reports that address the community's concerns. The commentor is referred to the Warminster Township Municipal Authority (WTMA) and Bucks County Department of Health for additional information. Under the auspices of the U.S. Center for Disease

Control, the Agency for Toxic Substances and Disease Registry (ATSDR) has also prepared a public health assessment for NAWC Warminster that may address this concern. A revised and updated public health assessment for NAWC is being prepared by ATSDR at this time.

IVYLAND BOROUGH SECRETARY - AUGUST 7, 2000

Comment 28: I am writing on behalf of the Ivyland Borough Council and the residents of Ivyland Borough. I myself am a resident of Wilson Avenue for the past thirty years. When I first moved to the Borough, most of the resident's water came from wells located on their properties. In light of the reports concerning the groundwater contamination on the former NAWC and the efforts by the Department of the Navy to clean up these areas, I am interested in knowing what implications there may be to residents who could have been exposed to these contaminants in the years before the current studies and results were made available to the public.

Response 28: See Response 27.

TABLES

TABLE 1

FREQUENCY OF DETECTION FOR HYDROGEOLOGIC UNIT A
DEC 1997/JAN 1998
NAWC WARMINSTER, PENNSYLVANIA

Compound	Frequency of Detection[1]	Range of Positive Detects	Location of Maximum	Average of Positive Results[2]	Average of All Results[3]	Federal MCL[4]
VOLATILES (Fg/L)						
1,1,1-Trichloroethane	6/13	0.6 - 340	W-HN-52S	94	44	200
1,1,2-Trichloroethane	1/13	0.7	W-HN-14S	0.7	2	5
1,1-Dichloroethane	6/13	0.6 - 190	W-HN-52S	36	18	--
1,1-Dichloroethene	6/13	0.6 - 210	W-HN-52S	44	21	7
1,2-Dichloroethane	1/13	1	W-HN-59S	1	2	5
Carbon Tetrachloride	5/13	3 - 12	W-SMC-01	7	4	5
Chloroform	2/13	2	W-HN-14S	2	3	80
Tetrachloroethene	10/13	1 - 420	W-HN-52S	60	46	5
Trichloroethene	12/13	0.7 - 360	W-HN-50S	133	123	5
cis-1,2-dichloroethene	6/13	0.9 - 7	W-HN-15S	2	3	70
INORGANICS (Fg/l)						
Antimony	1/3	4	W-HN-14S	4	1.9	6
Barium	1/3	40.7	W-HN-59S	40.7	21	2000
Calcium	3/3	27600 - 64400	W-HN-59S	42966 .6667	42966.6667	--
Chromium	3/3	7.5 - 72.1	W-HN-55S	35.6	35.566667	100
Magnesium	3/3	10700 - 2290	W-HN-59S	15666.6667	15666.6667	--
Nickel	1/3	7.8	W-HN-59S	7.8	4.7	100
Potassium	2/3	2510 - 3720	W-HN-55S	3115	2236/66667	--
Silver	2/3	2 - 3	W-HN-14S	2.5	1.9	100
Sodium	3/3	12200 - 40100	W-HN-55S	21833.3333	21833.333	--

Associated Samples:
W-HN-11X 12/23/97
W-HN-14S 12/17/97
W-HN-15S 12/10/97
W-HN-160 12/05/97
W-HN-16S 12/05/97
W-HN-19S 12/08/97
W-HN-50S 12/08/97
W-HN-50S-DUP 12/08/97
W-HN-52S 12/11/97
W-HN-55S 12/11/97
W-HN-59S 12/23/97
W-HN-65I1 12/04/97
W-SMC-01 12/22/97

MCL - Maximum Contaminant Level.
– denotes that no Federal MCL is available for this compound.
(1) - Duplicate samples are treated as separate samples.
(2) - Calculation of average using positive results only.
(3) - Calculation of average also considers one-half the nondetected values.
(4) - EPA Office of Water; Drinking Water Regulations and Health Advisories, October 1996.
(5) - Value is the secondary MCL

TABLE 2

FREQUENCY OF DETECTION FOR HYDROGEOLOGIC UNIT B
DEC 1997/JAN 1998
NAWC WARMINSTER, PENNSYLVANIA

Compound	Frequency of Detection[1]	Range of Positive Detects	Location of Maximum	Average of Positive Results[2]	Average of All Results[3]	Federal MCL[4]
VOLATILES (Fg/L)						
1,1,1-Trichloroethane	11/27	0.7 - 24	W-OS-757	3	8	200
1,1,2-Trichloroethane	4/27	4 - 67	W-HN-11I	31	12	5
1,1-Dichloroethane	15/27	0.4 - 19	W-OS-757	2	8	
1,1-Dichloroethene	17/27	0.5 - 22	W-OS-757	4	9	7
1,2-Dichloroethane	4/27	0.7 - 2	W-MW-EE	1	8	5
Acetone	1/3	16	W-OS-757	16	140	
Benzene	2/27	1 - 10	W-HN-11I	6	8	5
Carbon Disulfide	1/27	2	W-HN-11I	2	7	
Carbon Tetrachloride	13/27	1 - 990	W-HN-11I	160.846154	80	5
Chloroform	7/27	2 - 40	W-HN-11I	14	11	80
Ethylbenzene	1/27	4	W-HN-11I	4	8	700
Tetrachlorethene	24/27	0.8 - 160	W-HN-55I	47	44	5
Toluene	1/27	16	W-HN-11I	16	8	1000
Trans-1,2-dichloroethene	1/27	0.6	W-SMP-02	0.6	7	100
Trichloroethene	26/27	0.6 - 32000	W-HN-11I	2936	2828	5
Vinyl Chloride	3/27	0.9 - 4	W-SMP-02	2	8	2
Xylenes, Total	1/27	9	W-HN-11I	9	17	10000
cis-1,2-dichloroethene	16/27	0.6 - 72	W-HN-12S	16	16	70
INORGANICS (Fg/L)						
Aluminum	1/5	479	W-HN-55I	479	131	50-200[5]
Barium	4/5	54.1 - 112	W-HN-14I	84.175	78.2	2000
Calcium	5/5	42000 - 69300	W-HN-59I	60600	60600	
Chromium	5/5	12.2 - 43.9	W-HN-14I	20.4	20.4	100
Cyanide	1/5	6	W-HN-14I	6	3.2	200
Iron	3/5	291 - 29500	W-HN-11S	10065.3333	6052	300[5]
Lead	1/5	5.7	W-HN-11S	5.7	2	15[6]
Magnesium	5/5	16000 - 21100	W-HN-14I	18820	18820	
Manganese	2/5	154 - 201	W-HN-55I	177.5	73.0	50[5]
Mercury	1/5	0.56	W-HN-11S	0.56	0.2	2
Nickel	2/5	9.8 - 18.7	W-HN-14I	14.25	7.6	100
Potassium	5/5	1780 - 11100	W-HN-59I	5740	5740	
Silver	2/5	1.9 - 2.2	W-HN-59I-D	2.05	1.2	100
Sodium	5/5	16300 - 45700	W-HN-11S	25940	25940	
Zinc	1/5	60.7	W-HN-14I	60.7	19.6	5000[5]

TABLE 2

FREQUENCY OF DETECTION FOR HYDROGEOLOGIC UNIT B
DEC 1971/JAN 1998
NAWC WARMINSTER, PENNSYLVANIA

MCL - Maximum Contaminant Level.

– denotes that no Federal MCL is available for this compound.

(1) - Duplicate samples are treated as separate samples.

(2) - Calculation of average using positive results only.

(3) - Calculation of average also considers one-half the nondetected values.

(4) - EPA Office of Water; Drinking Water Regulations and Health Advisories, October 1996.

(5) - Value is the secondary MCL

(6) The value is an action level.

Associated Samples:

W-DG-12 12/22/97
W-DG-13 12/22/97
W-DG-130 12/22/97
W-HN-11I 12/23/97
W-HN-11S 12/23/97
W-HN-12S 12/23/97
W-HN-13S 12/19/97
W-HN-14I 12/17/97
W-HN-16I 12/05/97
W-HN-19I2 12/08/97
W-HN-22S 12/09/97
W-HN-50I 12/08/97
W-HN-52D 12/12/97
W-HN-52I 12/11/97
W-HN-55I 12/11/97
W-HN-59I 12/18/97
W-HN-59I-D 12/18/97
W-HN-65I2 12/04/97
W-HOBEN 12/09/97
W-MW-02 12/18/97
W-MW-D 12/22/97
W-MW-E 12/19/97
W-MW-EE 12/19/97
W-OS-757 12/17/97
W-SMP-02 12/19/97
W-WW-1 12/23/97
W-WW-10 12/23/97

TABLE 3

FREQUENCY OF DETECTION FOR HYDROGEOLOGIC UNIT C
DEC 1997/JAN 1998
NAWC WARMINSTER. PENNSYLVANIA

Compound	Frequency of Detection[1]	Range of Positive Detects	Location of Maximum	Average of Positive Results[2]	Average of All Results[3]	Federal MCL[4]
VOLATILES (Fg/L)						
1,1-Dichloroethane	1/6	1	W-HN-16D	1	0.6	
1,1-Dichloroethene	1/6	2	W-HN-16D	2	0.8	7
Acetone	1/1	8	W-HN-50D	8	8	
Tetrachloroethene	1/6	3	W-HN-221	3	0.9	5
Trichloroethene	4/6	0.5 - 4	W-HN-16D	2	2	5
cis-1,2-dichloroethene	1/6	0.5	W-HN-16D	0.5	0.5	70

Associated Samples:
W-HN-11D 12/18/97
W-HN-16D 12/05/97
W-HN-19D 12/08/97
W-HN-22I 12/09/97
W-HN-50D 12/09/97
W-HN-65D 12/04/97

MCL - Maximum Contaminant Level.

– denotes that no Federal MCL is available for this compound.

1 - Duplicate samples are treated as separate samples.

2 - Calculation of average using positive results only.

3 - Calculation of average also considers one-half the nondetected values.

4 - EPA Office of Water; Drinking Water Regulations and Health Advisories, October 1996.

TABLE 4

ANALYTICAL RESULTS FOR DETECTED COMPOUNDS
DURING PRESTART UP OF EXTRACTION WELLS
NAWC WARMINSTER, PENNSYLVANIA
PAGE 1 OF 2

WELL NAME	DAYS OF SYSTEM OPERATION	DILUTION FACTOR (SECONDARY DILUTION)	DATE SMPLE COLLECTED	ACETONE	BENZENE	BROMODICHLORO METHANE	2-BUTANONE	CARBON DISULFIDE	CARBON TETRACHLORIDE	CHLOROETHANE	CHLOROFORM	1,2-DICHLORO BENZENE	1,1-DICHLORO ETHANE	1,2-DICHLORO ETHANE	1,1-DICHLORO ETHENE	CIS-1,2-DICHLORO ETHENE
Extraction Wells																
EW-A1	-3	10	30-Jun-99	13 J	10 U	10 U	50 U	10 U	10 U	10 U	6 J	10 U	10 U	10 U	10 U	10 U
EW-A2	-3	1(20)	30-Jun-99	4 BJ	1 U	1 U	5 U	1 U	61 D	1 U	9	1 U	.07 J	1 U	2	4
EW-A3	-3	1(20)	30-Jun-99	5 B	1 U	1 U	5 U	1 U	140	1 U	8	1 U	2	0.7 J	1 U	2
EW-A4	-3	100	30-Jun-99	100 U	100 U	100 U	500 U	100 U	250	100 U	100 U	100 U	100 U	100 U	100 U	100 U
EW-A5	-3	1(100)	30-Jun-99	6	1	1 U	5 U	0.5 U	330 D	1 U	16	0.6 J	1 U	0.7 J	2	2
EW-A6	-3	1(2000)	30-Jun-99	12	42	1	5 U	5	6500 D	1 U	1 U	2	3	9	21	39
EW-A7	-3	100(2000)	30-Jun-99	190 J	100 U	100 U	500 U	100 U	5700	100 U	160	100 U	100 U	100 U	100 U	100 U
EW-A8	-3	2	30-Jun-99	7 J	2 U	2 U	10 U	2 U	7	2 U	2 U	2 U	2 U	2 U	2 U	2 U
EW-A9	-3	1(250)	30-Jun-99	7 B	6	1 U	5 U	2	1700 D	1 U	110	0.6 J	2	1 U	5	33
EW-A10	-3	50(500)	30-Jun-99	240 J	50 U	50 U	250 U	50 U	2000	50 U	81	50 U	50 U	50 U	50 U	50 U
EW-A11	-3	1	30-Jun-99	9	1 U	1 U	5 U	1 U	2	1 U	1	1 U	1 U	1 U	1 U	1 U
EW-A12	-3	1	30-Jun-99	7	1 U	1 U	0.7 J	1 U	4	1 U	1 U	1 U	0.8 J	1 U	1 U	34
EW-A13	-3	1	30-Jun-99	6	1 U	1 U	5 U	1 U	1 U	1 U	1	1 U	1 U	1 U	1 U	1 U
EW-A15	-3	1	30-Jun-99	7	1 U	1 U	5 U	1 U	1 U	1 U	0.9 J	1 U	0.9 J	1 U	0.7 J	2
		Frequency of Detection		13/14	3/14	1/14	1/14	3/14	11/14	0/14	10/14	3/14	6/14	3/14	5/14	7/14
Hydrogeologic Unit A																
HN-15S	-3	1(10)	28-Jun-99	4 BJ	1 U	1 U	5 U	1 U	3	1 U	3	1 U	1 U	1	2	230 D
HN-19S	-3	1	28-Jun-99	1 U	1 U	1 U	5 U	1 U	1 U	1 U	1 U	1 U	3	1 U	10	1 U
HN-52S	-3	1(25)	28-Jun-99	9	1 U	1 U	5 U	1 U	1 U	2	1 U	1 U	200	0.9 J	240 D	360 D
HN-55S	-3	1	29-Jun-99	8 B	1 U	1 U	5 U	1 U	2	1 U	2	1 U	1 U	1 U	1 U	1 U
HN-65I1	-3	1	28-Jun-99	5 B	1 U	1 U	5 U	1 U	1 U	1 U	1 U	1 U	23	1 U	30	18
HN-66S	-3	1	28-Jun-99	2 BJ	1 U	1 U	5 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	5
SMC-01	-3	1	29-Jun-99	5	1 U	1 U	5 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
		Frequency of Detection		6/7	0/7	0/7	0/7	0/7	2/7	1/7	2/7	0/7	3/7	2/7	4/7	4/7
Hydrogeologic Unit B																
HN-11S	-3	1(5)	29-Jun-99	5 B	0.6 J	1 U	5 U	1 U	1	1 U	7	1 U	1 U	1 U	1 U	2
HN-14I	-3	1(50)	29-Jun-99	4 J	1 U	1 U	5 U	1 U	180	1 U	15	1 U	1 U	1 U	3	16
HN-11I	-3	1(50)	29-Jun-99	7 B	2	1 U	0.7 J	0.6 J	250 D	1 U	12	1 U	1	0.9 J	4	3
HN-12S	-3	1	30-Jun-99	7	1 U	1 U	5 U	1 U	1	1 U	1 U	1 U	1 U	1 U	1 U	76
HN-13S	-3	1	29-Jun-99	7 B	1 U	1 U	5 U	1 U	1 U	1 U	1 U	1 U	2	1 U	2	1 U
HN-52D	-3	1	28-Jun-99	7 B	1 U	1 U	5 U	1 U	1 U	1 U	1 U	1 U	2	1 U	3	1
OB-A2	-3	1(20)	29-Jun-99	7	1 U	1 U	5 U	1 U	130	1 U	18	1 U	2	1 U	1 U	29
WMA-26	-3	1	28-Jun-99	7 B	1 U	1 U	5 U	1 U	1 U	1 U	0.9 J	1 U	15	1 U	17	8
HN-16I	-3	1(25)	29-Jun-99	4 BJ	1 U	1 U	5 U	1 U	91	1 U	11	1 U	0.7 J	0.7 J	2	13
HN-52I	-3	10	28-Jun-99	10 U	10 U	10 U	50 U	10 U	10 U	10 U	7 J	10 U	10 U	10 U	10 U	10 U
HN-55I	-3	1(5)	29-Jun-99	4 J	1 U	1 U	5 U	1 U	53	1 U	9	1 U	0.9 J	0.8 J	1	5
HN-59I	-3	1(50)	29-Jun-99	14	0.6 J	1 U	5 U	1 U	130	1 U	16	1 U	1 U	1 U	2	7
WW-1	-3	1	28-Jun-99	5 U	1 U	1 U	5 U	1 U	2	1 U	0.7 J	1 U	1 U	1 U	1 U	3
		Frequency of Detection		11/13	3/13	0/13	1/13	1/13	8/13	0/13	10/13	0/13	7/13	3/13	8/13	11/13
Hydrogeologic Unit C-No samples collected during this time period																
Between																
HN-15I	-3	1	29-Jun-99	5	1 U	1 U	5 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
HN-19I1	-3	1	28-Jun-99	6	1 U	1 U	5 U	1 U	1 U	1 U	0.8 J	1 U	2	1 U	16	1 U
		Frequency of Detection		2/2	0/2	0/2	0/2	0/2	0/2	0/2	1/2	0/2	1/2	0/2	1/2	0/2

TABLE 4

ANALYTICAL RESULTS FOR DETECTED COMPOUNDS
DURING PRESTART UP OF EXTRACTION WELLS
NAWC WARMINSTER, PENNSYLVANIA

WELL NAME	DAYS OF SYSTEM OPERATION	DILUTION FACTOR (SECONDARY DILUTION	DATE SAMPLE COLLECTED	TRANS 1,2-DICHLOROTHENE	ETHYLBENZENE	2-HEXANONE	4-METHYL-2-PENTANONE	METHYLENE CHLORIDE	1,1,2,2-TETRA CHLOROETHANE	TETRACHLORO EHENE (PCE)	TOLUENE	1,1,1-TRICHLORO ETHANE	1,1,2-TRICHLORO ETHANE	TRICHLORO EHENE (TCE)	VINYL CHLORIDE	XYLENES
Extraction Wells																
EW-A1	-3	10	30-Jun-99	10 U	10 U	50 U	50 U	43 B	10 U	91	10 U	10 U	10 U	930 B	10 U	10 U
EW-A2	-3	1(20)	30-Jun-99	1 U	1 U	5 U	5 U	1 B	1 U	130	1 U	1 U	7	2300 BD	1 U	3 U
EW-A3	-3	1(20)	30-Jun-99	1 U	1 U	5 U	5 U	1 B	1 U	45	1 U	1 U	8	4000 BD	1 U	3 U
EW-A4	-3	100	30-Jun-99	100 U	100 U	500 U	500 U	220 B	100 U	100 U	100 U	100 U	100 U	8800 B	100 U	300 U
EW-A5	-3	1(100)	30-Jun-99	1 U	1	5 U	5 U	3 B	1 U	20	5	1 U	9	9600 BD	1 U	9
EW-A6	-3	1(2000)	30-Jun-99	1 U	76	5 U	1 J	11 B	0.6 J	1 U	1 U	1 U	1 U	240000 BD	1 U	3 U
EW-A7	-3	100(2000)	30-Jun-99	100 U	53 J	500 U	500 U	270 B	100 U	260	360	100 U	260	150000 D	100 U	320
EW-A8	-3	2	30-Jun-99	2 U	2 U	10 U	10 U	9 B	2 U	28	2 U	2 U	2 U	180 B	2 U	6 U
EW-A9	-3	1(250)	30-Jun-99	1 U	3	5 U	5 U	18 B	1 U	370 D	19	1 U	61	46000 D	0.7 J	26
EW-A10	-3	50(500)	30-Jun-99	50 U	50 U	250 U	250 U	140 B	50 U	390	57	50 U	86	72000 BD	50 U	64
EW-A11	-3	1	30-Jun-99	1 U	1 U	5 U	5 U	15 B	1 U	6	1 U	1 U	1 U	62	1 U	3 U
EW-A12	-3	1	30-Jun-99	1 U	1 U	5 U	5 U	8 B	1 U	69	1 U	1 U	1 U	70	1 U	3 U
EW-A13	-3	1	30-Jun-99	1 U	1 U	5 U	5 U	5 B	1 U	3	1 U	1 U	1 U	3 B	1 U	3 U
EW-A15	-3	1	30-Jun-99	1 U	1 U	5 U	5 U	1	1 U	13	1 U	1 U	1 U	13	1 U	3 U
		Frequency of Detection		0/14	4/14	0/14	1/14	14/14	1/14	12/14	4/14	0/14	6/14	14/14	1/14	4/14
Hydrogeologic Unit A																
HN-15S	-3	1(10)	28-Jun-99	1 U	1 U	5 U	5 U	1 U	1 U	16	1 U	1 U	1	780 BD	8	3 U
HN-19S	-3	1	28-Jun-99	1 U	1 U	5 U	5 U	1 U	1 U	1 U	1 U	3	1 U	1 U	1 U	3 U
HN-52S	-3	1(25)	28-Jun-99	1 U	1 U	5 U	5 U	1 B	1 U	2100 D	1 U	480 D	1 U	390 D	1 U	3 U
HN-55S	-3	1	29-Jun-99	1 U	1 U	5 U	5 U	9 B	1 U	1 U	1 U	1 U	1 U	120 B	1 U	3 U
HN-65I1	-3	1	28-Jun-99	1 U	1 U	5 U	5 U	0.8 J	1 U	99	1 U	27	1 U	100	1 U	3 U
HN-66S	-3	1	28-Jun-99	1 U	1 U	5 U	5 U	1 U	1 U	9	1 U	1 U	1 U	5	1 U	3 U
SMC-01	-3	1	29-Jun-99	1 U	1 U	5 U	5 U	6 B	1 U	1 U	1 U	1U	1U	3 B	1 U	3 U
		Frequency of Detection		0/7	0/7	0/7	0/7	4/7	0/7	4/7	0/7	3/7	1/7	6/7	1/7	0/7
Hydrogeologic Unit B																
HN-11S	-3	1(5)	29-Jun-99	1 U	1 U	5 U	5 U	2 B	1 U	0.9 J	1 U	1 U	1 U	570 BD	1 U	3 U
HN-14I	-3	1(50)	29-Jun-99	1 U	1 U	5 U	5 U	1 B	1 U	97	1 U	1 U	13	7300 D	1 U	3 U
HN-11I	-3	1(50)	29-Jun-99	1 U	1 U	5 U	5 U	10 B	1 U	16	1 U	1 U	18	8500 BD	1 U	1 J
HN-12S	-3	1	30-Jun-99	0.7 J	1 U	5 U	5 U	1 B	1 U	100	1 U	1 U	1 U	61 B	1 U	3 U
HN-13S	-3	1	29-Jun-99	1 U	1 U	5 U	5 U	6 B	1 U	4	1 U	1 U	1 U	11	1 U	3 U
HN-52D	-3	1	28-Jun-99	1 U	1 U	5 U	5 U	4	1 U	0.6 J	1 U	1 U	1 U	26	1 U	3 U
OB-A2	-3	1(20)	29-Jun-99	3	1 U	5 U	5 U	2 B	1 U	140 D	1 U	1 U	3	1200 D	1 U	3 U
WMA-26	-3	1	28-Jun-99	1 U	1 U	5 U	5 U	11	1 U	70	1 U	18	1 U	160	1 U	3 U
HN-16I	-3	1(25)	29-Jun-99	1 U	1 U	5 U	5 U	1	1 U	65	1 U	1 U	9	3500 BD	1 U	3 U
HN-52I	-3	10	28-Jun-99	10 U	10 U	50 U	50 U	16	10 U	45	10 U	10 U	10 U	920	10 U	30 U
HN-55I	-3	1(5)	29-Jun-99	1 U	1 U	5 U	5 U	1 B	1 U	180 D	1 U	1 U	1	370 D	1 U	3 U
HN-59I	-3	1(50)	29-Jun-99	1 U	1 U	5 U	5 U	1 B	1 U	93	1 U	1 U	14	5700 D	1 U	3 U
WW-1	-3	1	28-Jun-99	1 U	1 U	5 U	5 U	2 B	1 U	6	1 U	1 U	1 U	71	1 U	3 U
		Frequency of Detection		2/13	0/13	0/13	0/13	13/13	0/13	13/13	0/13	1/13	6/13	13/13	0/13	1/13
Hydrogeologic Unit C - No samples collected during this tim																
Between																
HN-15I	-3	1	29-Jun-99	1 U	1 U	5 U	5 U	1 B	1 U	1 U	1 U	1 U	1 U	8 B	1 U	3 U
HN-19I1	-3	1	28-Jun-99	1 U	1 U	0.6 J	5 U	5 B	1 U	0.6 J	1 U	3	1 U	3	1 U	3 U
		Frequency of Detection		0/2	0/2	1/2	0/2	2/2	0/2	1/2	0/2	1/2	0/2	2/2	0/2	0/2

Notes: * indicates a diluted result.
"Days -3" Sampling Event was 28-30 June 1999
Only detected analytesl are shown on this table

Qualifiers: All results are in ppb
U = Analyte was not detected at the stated quantitation limit.
J = Analyte result is "estimated" because either the analyte was detected at a levelbelow the quantitation limit, or for other reasons.
B = Analyte was not detected in the associated method blank as well as in the sample.
D = The initial analysis for this compound exceeded the calibration range, so this result is from thesecondary dilution indicated.

TABLE 5

ANALYTICAL RESULTS FOR DETECTED COMPOUNDS
FOR PERFORMENACE MONITORING DAYS 6, 14, AND 21
NAWC WARMINSTER, PENNSYLVANIA
PAGE 1 OF 2

WELL NAME	DAYS OF SYSTEM OPERATION	DILUTION FACTOR (SECONDARY DILUTION	DATE SAMPLE COLLECTED	ACETONE	BENZENE	BROMODICHLORO METHANE	2-BUTANONE	CARBON DISULFIDE	CARBON TETRACHLORIDE	CHLOROFORM	1,2-DICHLORO BENZENE	1,1-DICHLORO ETHANE	1,2-DICHLORO ETHANE	1,1-DICHLORO ETHENE
EW-A1	6	25	28-Jul-99	120 U	25 U	25 U	120 U	25 U	65	25 U	25 U	25 U	25 U	25 U
EW-A1	14	10	31-Aug-99	50 U	10 U	10 U	50 U	10 U	31	10 U	10 U	10 U	10 U	6 U
EW-A1	21	50	7-Sep-99	93 J	50 U	50 U	250 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
EW-A1O	6	50	28-Jul-99	170 J	50 U	50 U	250 U	50 U	240	50 U	50 U	50 U	50 U	50 U
EW-A1O	14	500	31-Aug-99	480 BJ	500 U	500 U	2500 U	500 U	760	500 U	500 U	500 U	500 U	500 U
EW-A1O	21	1000	7-Sep-99	5000 U	1000 U	1000 U	5000 U	1000 U	1800	1000 U	1000 U	1000 U	1000 U	1000 U
EW-A11	6	2	28-Jul-99	10 U	2 U	2 U	10 U	2 U	40	8	2 U	1 J	2 U	4
EW-A11	14	1	31-Aug-99	4 J	1 U	1 U	1 J	1 U	8	2	1 U	1 U	1 U	1 U
EW-A11	21	5	10-Sep-99	6 BJ	5 U	5 U	25 U	5 U	14	4 J	5 U	5 U	5 U	5 U
EW-A12	14	1 (10)	31-Aug-99	5 U	1 U	1 U	5 U	1 U	100	10	1 U	1	0.6 J	1 U
EW-A12	21	1 (20)	7-Sep-99	10 B	1 U	1 U	5 U	1 U	57	9	1 U	1	1 U	0.6 J
EW-A13	6	2	28-Jul-99	13	2 U	2 U	10 U	2 U	30	5	2 U	2 U	2 U	2
EW-A13	14	1 (10)	31-Aug-99	3 J	1 U	1 U	5 U	1 U	54	8	1 U	0.6 J	0.9 J	2
EW-A13	21	1	7-Sep-99	5	1 U	1 U	0.8 J	1 U	24	4	1 U	1 U	1 U	0.8 J
EW-A15	6	1	28-Jul-99	5 U	1 U	1 U	5 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
EW-A15	14	1	31-Aug-99	3 J	1 U	1 U	5 U	1 U	1 U	1 U	1 U	0.7 J	1 U	1 U
EW-A15	21	1	7-Sep-99	8 B	1 U	1 U	1 J	1 U	0.5 J	1	1 U	0.8 J	1 U	0.8 J
EW-A2	6	50	28-Jul-99	130 J	50 U	50 U	250 U	50 U	150 U	50 U	50 U	50 U	50 U	50 U
EW-A2	14	1 (20)	31-Aug-99	5 U	1 U	1 U	5 U	1 U	81	7	1 U	0.6 J	0.6 J	3
EW-A2	21	100	7-Sep-99	120 J	100 U	100 U	500 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U
EW-A3	6	100	28-Jul-99	300 J	100 U	100 U	500 U	100 U	330	100 U	100 U	100 U	100 U	100 U
EW-A3	14	1 (50)	31-Aug-99	4 J	1	1 U	5 U	1 U	240*	17	1 U	1	1	4
EW-A3	21	100	7-Sep-99	94 J	100 U	100 U	500 U	100 U	160	100 U	100 U	100 U	100 U	100 U
EW-A4	6	250	28-Jul-99	670 J	250 U	250 U	1200 U	250 U	730	250 U	250 U	250 U	250 U	250 U
EW-A4	14	1 (200)	31-Aug-99	5	8	1 U	5 U	0.7 J	990*	69	1 U	0.9 J	3	7
EW-A4	21	500	7-Sep-99	2500 U	500 U	500 U	2500 U	500 U	710	500 U	500 U	500 U	500 U	500 U
EW-A5	14	100 (1000)	1-Sep-99	500 U	100 U	100 U	500 U	100 U	1100	100 U	100 U	100 U	100 U	100 U
EW-A5	21	500	10-Sep-99	2500 U	500 U	500 U	2500 U	500 U	840	500 U	500 U	500 U	500 U	500 U
EW-A6	6	1000	28-Jul-99	2800 J	1000 U	1000 U	5000 U	1000 U	4100	1000 U	1000 U	1000 U	1000 U	1000 U
EW-A6	14	1 (500)	31-Aug-99	8	13	0.6 J	5 U	3	2500*	180	0.9 J	2	5	9
EW-A6	21	5000	10-Sep-99	25000 U	5000 U	5000 U	25000 U	5000 U	4300 J	5000 U	5000 U	5000 U	5000 U	5000 U
EW-A7	6	500	28-Jul-99	2500 U	500 U	500 U	2500 U	500 U	1500	500 U	500 U	500 U	500 U	500 U
EW-A7	14	1000	31-Aug-99	5000 U	1000 U	1000 U	5000 U	1000 U	3800	1000 U	1000 U	1000 U	1000 U	1000 U
EW-A7	21	5000	10-Sep-99	25000 U	5000 U	5000 U	25000 U	5000 U	4800 J	5000 U	5000 U	5000 U	5000 U	5000 U
EW-A8	6	10	28-Jul-99	50 U	10 U	10 U	50 U	10U	35	10 U	10 U	10 U	10 U	10 U
EW-A8	14	10	31-Aug-99	50 U	10 U	10 U	50 U	10 U	6 J	10 U	10 U	10 U	10 U	10 U
EW-A8	21	10	7-Sep-99	23 J	10 U	10 U	50 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
EW-A9	14	1000	1-Sep-99	5000 U	1000 U	1000 U	5000 U	1000 U	1400	1000 U	1000 U	1000 U	1000 U	1000 U
EW-A9	21	1000	10-Sep-99	5000 U	1000 U	1000 U	5000 U	1000 U	1300	1000 U	1000 U	1000 U	1000 U	1000 U
HN-50D	14	1	1-Sep-99	5 U	1 U	1 U	5 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
HN-50D	21	5	10-Sep-99	21 BJ	5 U	5 U	25 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
HN-50I	14	1	1-Sep-99	6 B	1 U	1 U	5 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
HN-50I	21	1	10-Sep-99	4 BJ	1 U	1 U	5 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
HN-50S	14	5	1-Sep-99	25 U	5 U	5 U	25 U	5 U	9	5 U	5 U	5 U	5 U	5 U
HN-50S	21	25	10-Sep-99	63 J	25 U	25 U	120 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U

TABLE 5
ANALYTICAL RESULTS FOR DETECTED COMPOUNDS
FOR PERFORMENACE MONITORING DAYS 6, 14, AND 21
NAWC WARMINSTER. PENNSYLVANIA
PAGE 2 OF 2

WELL NAME	DAYS OF SYSTEM OPERATION	DILUTION FACTOR (SECONDARY DILUTION	DATE SAMPLE COLLECTED	CIS-1,2-DICHLORO ETHENE	ETHYLBENZENE	2-HEXANONE	METHYLENE CHLORIDE	TETRACHLORO ETHENE (PCE)	TOLUENE	1,1,1-TRICHLORO ETHANE	1,1,2-TRICHLORO ETHANE	TRICHLORO ETHENE (TCE)	VINYL CHLORIDE	XYLENES
EW-A1	6	25	28-Jul-99	25 U	25 U	120 U	110 B	45	25 U	25 U	25 U	2800	25 U	75 U
EW-A1	14	10	31-Aug-99	10 U	10 U	50 U	14	20	10 U	10 U	10 U	1300	10 U	30 U
EW-A1	21	50	7-Sep-99	50 U	50 U	250 U	63	50 U	50 U	50 U	50 U	1300	50 U	150 U
EW-A1O	6	50	28-Jul-99	50 U	50	250 U	240 U	250	50 U	50 U	50 U	4000	50 U	150 U
EW-A1O	14	500	31-Aug-99	500 U	500 U	2500 U	290 J	250 J	500 U	500 U	500 U	20000	500 U	1500 U
EW-A1O	21	1000	7-Sep-99	1000 U	1000 U	5000 U	1000 U	1000 U	1000 U	1000 U	1000 U	52000	1000 U	3000 U
EW-A11	6	2	28-Jul-99	6	2 U	10 U	14 B	300	2 U	2 U	2 U	59	2 U	6 U
EW-A11	14	1	31-Aug-99	2	1 U	5 U	0.8 J	61	1 U	1 U	1 U	15	1 U	3 U
EW-A11	21	5	10-Sep-99	4 J	5 U	25 U	3 J	130	5 U	5 U	5 U	34	5 U	15 U
EW-A12	14	1 (10)	31-Aug-99	49	1 U	5 U	1	160	1 U	1 U	1	1300 BD	1 U	3 U
EW-A12	21	1 (20)	7-Sep-99	40	1 U	5 U	1	130	1 U	0.6 J	1 U	690 D	1 U	3 U
EW-A13	6	2	28-Jul-99	2	2 U	10 U	13 B	200	2 U	2 U	2 U	30	2 U	6 U
EW-A13	14	1 (10)	31-Aug-99	6	1 U	5 U	0.6 J	350 D	1 U	1 U	1 U	50	1 U	3 U
EW-A13	21	1	7-Sep-99	2	1 U	5 U	0.6 J	140	1 U	1 U	1 U	25	1 U	3 U
EW-A15	6	1	28-Jul-99	2	1 U	5 U	3 B	11	1 U	1 U	1 U	10	1 U	3 U
EW-A15	14	1	31-Aug-99	3	1 U	5 U	0.7 J	14	1 U	1 U	1 U	12 B	1 U	3 U
EW-A15	21	1	7-Sep-99	3	1 U	5 U	3 B	15	1 U	1 U	1 U	14	1 U	3 U
EW-A2	6	50	28-Jul-99	50 U	50 U	250 U	280 U	73	50 U	50 U	50 U	6000	50 U	150 U
EW-A2	14	1 (20)	31-Aug-99	7	1 U	5 U	1	47	1 U	1 U	6	2900 B*	1 U	3 U
EW-A2	21	100	7-Sep-99	100 U	100 U	500 U	100	100 U	100 U	100 U	100 U	2100	100 U	300 U
EW-A3	6	100	28-Jul-99	100 U	100 U	500 U	360 B	220	100 U	100 U	100 U	1200	100 U	300 U
EW-A3	14	1 (50)	31-Aug-99	9	1 U	5 U	1	180*	1 U	0.8 J	14	8400 B*	1 U	3 U
EW-A3	21	100	7-Sep-99	100 U	100 U	500 U	92 J	220	100 U	100 U	100 U	6200	100 U	300 U
EW-A4	6	250	28-Jul-99	250 U	250 U	1200 U	1100 U	250 U	250 U	250 U	250 U	31000	250 U	750 U
EW-A4	14	1 (200)	31-Aug-99	13	0.9 J	5 U	4	110	8	1 U	88	40000*	0.8 J	3
EW-A4	21	500	7-Sep-99	500 U	500 U	2500 U	460 U	500 U	500 U	500 U	500 U	32000	500 U	380 J
EW-A5	14	100 (1000)	1-Sep-99	100 U	100 U	500 U	100 U	100 U	100 U	100 U	100 U	36000*	100 U	300 U
EW-A5	21	500	10-Sep-99	500 U	500 U	2500 U	390 U	500 U	500 U	500 U	500 U	23000	500 U	1500 U
EW-A6	6	1000	28-Jul-99	1000 U	1000 U	5000 U	4800 U	590 U	1000 U	1000 U	1000 U	160000	100 U	3000 U
EW-A6	14	1 (500)	31-Aug-99	24	20	5 U	13	380 J*	100	1 U	120	93000*	1	130
EW-A6	21	5000	10-Sep-99	5000 U	5000 U	25000 U	3000 U	5000 U	5000 U	5000 U	5000 U	210000	5000 U	15000 U
EW-A7	6	500	28-Jul-99	500 U	500 U	2500 U	1900 B	500 U	500 U	500 U	500 U	67000	500 U	1500 U
EW-A7	14	1000	31-Aug-99	1000 U	1000 U	590 J	1000 U	1000 U	1000 U	1000 U	1000 U	120000	1000 U	3000 U
EW-A7	21	5000	10-Sep-99	5000 U	5000 U	25000 U	2800 J	5000 U	5000 U	5000 U	5000 U	190000	5000 U	15000 U
EW-A8	6	10	28-Jul-99	10 U	10 U	50 U	42 B	33	10 U	10 U	10 U	1500	10 U	30 U
EW-A8	14	10	31-Aug-99	10 U	10 U	50 U	8 J	9 J	10 U	10 U	10 U	480	10 U	30 U
EW-A8	21	10	7-Sep-99	10 U	10 U	50 U	9 J	8 J	10 U	10 U	10 U	320	10 U	30 U
EW-A9	14	1000	1-Sep-99	1000 U	1000 U	5000 U	630 U	1000 U	1000 U	1000 U	1000 U	50000	1000 U	3000 U
EW-A9	21	1000	10-Sep-99	1000 U	1000 U	5000 U	560 J	1000 U	1000 U	1000 U	1000 U	44000	1000 U	3000 U
HN-50D	14	1	1-Sep-99	1 U	1 U	5 U	1 U	1 U	1 U	1 U	1 U	42	1 U	3 U
HN-50D	21	5	10-Sep-99	5 U	5 U	25 U	3 J	5 U	5 U	5 U	5 U	100	5 U	15 U
HN-50I	14	1	1-Sep-99	1 U	1 U	5 U	0.5 J	1 U	1 U	1 U	1 U	2	1 U	3 U
HN-50I	21	1	10-Sep-99	1 U	1 U	5 U	3 B	1 U	1 U	1 U	1 U	3	1 U	3 U
HN-50S	14	5	1-Sep-99	5 U	5 U	25 U	4 J	5 U	5 U	5 U	5 U	360	5 U	15 U
HN-50S	21	25	10-Sep-99	25 U	25 U	120 U	20 J	26	25 U	25 U	25 U	470	25 U	75 U

* Indicates a diluted result.

Notes: Day 6 (7/28/99 to 7/29/99); Day 14 (8/31/99 to 9/1/99); Day 21 (9/7/99 to 9/10/99)
Only detected analytes are shown on this table
All results are in ppb

Qualifiers: U=Analyte was not detected at the stated quantitation limit.
J=Analyte result is "estimated" because either the analyte was detected at a level
Below the quantitation limit, or for other reasons.
B=Analyte was also detected in the associated method blank as well as in the sample.
D=The initial analysis for this compound exceeded the calibration range, so this result is from
The secondary dilution indicated:

TABLE 6

ANALYTICAL RESULTS FOR DETECTED COMPOUNDS
FOR PERFORMANCE MONITORING MONTHS 1, 2, AND 3
NAWC WARINSTER, PENNSYLVANIA
PAGE 1 OF 2

WELL NAME	DAYS OF SYSTEM OPERATION	DILUTION FACTOR (SECONDARY DILUTION)	DATE SAMPLE COLLECTED	ACETONE	BROMODICHLORO METHANE	2-BUTANONE	CARBON DISULFIDE	CARBON TETRACHORIDE	CHLOROFORM	1,1-DICHLORO ETHANE	1,2-DICHLORO ETHANE	1,1-DICHLORO ETHENE	CIS-1,2-DICHLORO ETHENE	TRANS-1,2 DICHLORIDETHENE	METHYLENE CHLORIDE	1,1,2,2-TETRA CHLORIDETHANE	TETRACHLORO ETHENE (PCE)	1,1,1-TRICHLORO ETHANE	1,1,2-TRICHLORO ETHANE	TRICHLORO ETHENE (TCE)	VINYL CHLORIDE
Extraction Wells																					
EW-A1	Month 1	50	15-Sep-99	250 U	50 U	250 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	41 J	50 U	50 U	50 U	50 U	1100	50 U
EW-A1	Month 2	5	14-Oct-99	10 U	5 U	10 U	5 U	14	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	16	5 U	5 U	780	5 U
EW-A1	Month 3	5	15-Nov-99	25 U	5 U	25 U	5 U	8	5 U	5 U	5 U	5 U	5 U	5 U	13	5 U	7	5 U	5 U	470	5 U
EW-A2	Month 1	50	14-Sep-99	170 BJ	50 U	140 U	50 U	45 U	50 U	50 U	50 U	50 U	50 U	50 U	160 U	50 U	35 U	50 U	50 U	2300	50 U
EW-A2	Month 2	10	14-Oct-99	20 U	10 U	20 U	10 U	18	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	16	10 U	10 U	940	10 U
EW-A2	Month 3	10	15-Nov-99	50 U	10 U	50 U	10 U	17	10 U	10 U	10 U	10 U	10 U	10 U	14	10 U	16	10 U	10 U	850	10 U
EW-A3	Month 1	200	15-Sep-99	1000 U	200 U	1000 U	200 U	160 U	200 U	200 U	200 U	200 U	200 U	200 U	170 U	200 U	160 U	200 U	200 U	6800	200 U
EW-A3	Month 2	25	14-Oct-99	50 U	25 U	50 U	25 U	69	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	63	25 U	25 U	3100	25 U
EW-A3	Month 3	100	15-Nov-99	500 U	100 U	500 U	100 U	97 J	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	70 J	100 U	100 U	3900	100 U
EW-A4	Month 1	1000	15-Sep-99	5000 U	1000 U	5000 U	1000 U	790 J	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	890 J	1000 U	1000 U	1000 U	1000 U	39000	1000 U
EW-A4	Month 2	250	14-Oct-99	500 U	250 U	500 U	250 U	630	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	27000	250 U
EW-A4	Month 3	250	15-Nov-99	1200 U	250 U	1200 U	250 U	590	250 U	250 U	250 U	250 U	250 U	250 U	290	250 U	130 J	250 U	250 U	28000	250 U
EW-A5	Month 1	1000	15-Sep-99	5000 U	1000 U	5000 U	1000 U	800 J	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1300	1000 U	1000 U	1000 U	1000 U	27000	1000 U
EW-A5	Month 3	20(1000)	23-Nov-99	5000 U	1000 U	1000 U	830 DJ	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	22000 D	1000 U
EW-A6	Month 1	5000	15-Sep-99	25000 U	5000 U	25000 U	5000 U	2600 U	5000 U	5000 U	5000 U	5000 U	5000 U	5000 U	4100 J	5000 U	5000 U	5000 U	5000 U	120000	5000 U
EW-A6	Month 2	1000	14-Oct-99	2000 U	1000 U	2000 U	1000 U	3800	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	510 J	1000 U	1000 U	150000	1000 U
EW-A7	Month 1	5000(1000)	15-Sep-99	50000 U	5000 U	50000 U	5000 U	6900	5000 U	5000 U	5000 U	5000 U	5000 U	5000 U	500	5000 U	5000 U	5000 U	5000 U	280000	5000 U
EW-A7	Month 2	1000	14-Oct-99	2000 U	1000 U	2000 U	1000 U	5500	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	200000	1000 U
EW-A7	Month 3	2000	15-Nov-99	10000 U	2000 U	10000 U	2000 U	5500	2000 U	2000 U	2000 U	2000 U	2000 U	2000 U	2000 U	2000 U	2000 U	2000 U	2000 U	170000	2000 U
EW-A8	Month 1	10	14-Sep-99	16 J	10 U	50 U	10 U	7 J	10 U	9 J	10 U	10 U	10 U	10 U	10 U	10 U	8 J	10 U	10 U	390	10 U
EW-A8	Month 2	2(5)	14-Oct-99	4 U	2 U	4 U	2 U	16	2	2 U	2 U	2 U	4	2 U	2 U	2 U	20	2 U	2 U	810 D	2 U
EW-A8	Month 3	10(20)	23-Nov-99	27 BDJ	20 U	100 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	400 D	20 U
EW-A9	Month 1	1000	15-Sep-99	5000 U	1000 U	5000 U	1000 U	1700	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	47000	1000 U
EW-A9	Month 3	1000(2500)	19-Nov-99	2100 DJ	2500 U	1200 U	2500 U	3000 D	2500 U	2500 U	2500 U	2500 U	2500 U	2500 U	2500 U	2500 U	2500 U	2500 U	2500 U	110000 D	2500 U
EW-A10	Month 1	1000	15-Sep-99	5000 U	1000 U	5000 U	1000 U	1800	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	930 J	1000 U	1000 U	1000 U	1000 U	48000	1000 U
EW-A10	Month 2	500	14-Oct-99	1000 U	500 U	1000 U	500 U	1800 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	490 J	500 U	500 U	49000	500 U
EW-A10	Month 3	2000	16-Nov-99	8000 BJ	2000 U	10000 U	2000 U	2000 U	2000 U	2000 U	2000 U	2000 U	2000 U	2000 U	1200 J	2000 U	2000 U	2000 U	2000 U	27000	2000 U
EW-A11	Month 1	2	15-Sep-99	8 BJ	2 U	10 U	2 U	11	2 U	2 U	2 U	2 U	3	2 U	1 BJ	2 U	91	2 U	2 U	24	2 U
EW-A11	Month 2	1	14-Oct-99	2 U	1 U	2 U	1 U	13	3	1	1 U	1 U	3	1 U	1 U	1 U	110	1 U	1 U	26	1 U
EW-A11	Month 3	5	17-Nov-99	7 J	5 U	25 U	5 U	13	3 J	5 U	5 U	4 J	5 U	5 U	5 U	5 U	120	5 U	5 U	28	5 U
EW-A12	Month 1	5	15-Sep-99	20 J	5 U	25 U	5 U	18	4 J	5 U	5 U	5 U	46	5 U	7	5 U	76	5 U	5 U	200	5 U
EW-A12	Month 2	5	14-Oct-99	10 U	5 U	10 U	5 U	28	5	5 U	5 U	5 U	38	5 U	5 U	5 U	130	5 U	5 U	400	5 U
EW-A12	Month 3	2(20)	15-Nov-99	10 U	2 U	10 U	2 U	140	10	2 U	2 U	2 U	22	2 U	1 J	2 U	150	2 U	3	2600 D	2 U
EW-A13	Month 1	5	15-Sep-99	17 J	5 U	25 U	5 U	25	5	5 U	5 U	5 U	4 J	5 U	6	5 U	190	5 U	5 U	32	5 U
EW-A13	Month 2	1(2)	14-Oct-99	2 U	1 U	2 U	1 U	31	5	1 U	1 U	3	4	1 U	1 U	1 U	190 D	1	1 U	33	1 U
EW-A13	Month 3	5(10)	17-Nov-99	5 J	5 U	25 U	5 U	39	6	5 U	5 U	3 J	5	5 U	5 U	5 U	250 D	5 U	5 U	42	5 U
EW-A15	Month 1	1	15-Sep-99	4 J	1 U	5 U	1 U	0.6 J	1	1 U	1 U	1 U	3	1 U	1	1 U	15	1 U	1 U	12	1 U
EW-A15	Month 2	1	14-Oct-99	2 U	1 U	2 U	1 U	1 U	0.8 J	0.6 J	1 U	1 U	1 U	1 U	1 U	13	13	1 U	1 U	10	1 U
EW-A15	Month 3	1	15-Nov-99	5 U	1 U	5 U	1 U	1U	1	0.8 J	1 U	1 U	4	1 U	1 U	1 U	17	1 U	1 U	13	1 U
Hydrogeologic Unit A																					
HN-15S	Month 1	1	20-Sep-99	5 U	1 U	1 U	5 U	1 U	1 U	1 U	1 U	1 U	1 U	11	1 U	1 U	1 U	1 U	1 U	20	5
HN-19S	Month 3	1	17-Nov-99	1 J	1 U	5 U	1 U	1 U	1 U	2	1 U	6	1 U	1 U	1 U	1 U	1 U	3	1 U	1 U	1 U
HN-50S	Month 1	5	15-Sep-99	4 BJ	5 U	25 U	5 U	6	5 U	5 U	5 U	5 U	5 U	5 U	3 BJ	5 U	7	5 U	5 U	350	5 U
HN-50S	Month 3	20	17-Nov-99	18 J	20 U	100 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	22	20 U	20 U	20 U	20 U	290	20 U

TABLE 6

ANALYTICAL RESULTS FOR DETECTED COMPOUNDS
FOR PERFORMANCE MONITORING MONTHS 1, 2, AND 3
NAWC WARINSTER, PENNSYLVANIA
PAGE 2 OF 2

WELL NAME	DAYS OF SYSTEM OPERATION	DILUTION FACTOR (SECONDARY DILUTION)	DATE SAMPLE COLLECTED	ACETONE	BROMODICHL ORO METHANE	2-BUTANONE	CARBON DISULFIDE	CARBON TETRACHORIDE	CHLOROFORM	1,1-DICHLORO ETHANE	1,2-DICHLORO ETHANE	1,1-DICHLORO ETHENE	CIS-1,2-DICHLORO ETHENE	TRANS-1,2 DICHLORIDETHENE	METHYLENE CHLORIDE	1,1,2,2-TETRA CHLORIDETHANE	TETRACHLORO ETHENE (PCE)	1,1,1-TRICHLORO ETHANE	1,1,2-TRICHLORO ETHANE	TRICHLORO ETHENE (TCE)	VINYL CHLORIDE
HN-52S	Month 3	100	17-Nov-99	220 J	100 U	500 U	100 U	100 U	100 U	180	100 U	350	490	100 U	99 J	100 U	4800	780	100 U	1000	100 U
HN-55S	Month 3	1	10-Nov-99	2 BJ	1 U	5 U	1U	3	2	1 U	1 U	1 U	1 U	1 U	1 U	1 U	0.6 J	1 U	1 U	120	1 U
HN-59S	Month 3	1(20)	23-Nov-99	34 BDJ	20 U	100 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	37 D	20 U	20 U	20 U	20 U	420 D	20 U
SMC-01	Month 3		17-Nov-99	2 J	1 U	5 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	3	1 U	1 U	0.6 J	1 U
Hydrogeologic Unit B																					
HN-11S	Month 3	20	23-Nov-99	25 J	27	100 U	20 U	23	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	3300	20 U
HN-12S	Month 3	1(5)	17-Nov-99	3 J	1 U	5 U	1 U	0.7 J	15	2	1 U	1 U	130 D	2	1 U	1 U	140 D	4	1 U	88 D	0.6 J
HN-13S	Month 3	1	17-Nov-99	2 J	1 U	5 U	1 U	1 U	1 U	2	1 U	1	1	1	1 U	1 U	4	0.9 J	1 U	11	1 U
HN-11I	Month 1	2500	15-Sep-99	2200 BJ	2500 U	12000 U	2500 U	1800 J	2500 U	2500 U	2500 U	2500 U	2500 U	2500 U	2200 BJ	2500 U	2500 U	2500 U	2500 U	92000	2500 U
HN-11I	Month 3	2500	23-Nov-99	12000 U	2500 U	2500 U	2500 U	1400 U	2500 U	2500 U	2500 U	2500 U	2500 U	2500 U	2500 U	2500 U	2500 U	2500 U	2500 U	83000	2500 U
HN-14I	Month 1	50	20-Sep-99	100 BJ	50 U	250 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	60	50 U	50 U	50 U	50 U	1200	50 U
HN-14I	Month 3	50	19-Nov-99	250 U	50 U	250 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	130	50 U	50 U	50 U	50 U	1500	50 U
HN-15S	Month 1	1	20-Sep-99	5 U	1 U	5 U	1 U	1 U	1 U	1 U	1 U	1 U	11	1 U	1 U	1 U	1 U	1 U	1 U	20	5
HN-16I	Month 1	50	20-Sep-99	120 BJ	50 U	250 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	60	50 U	25 J	50 U	50 U	1800	50 U
HN-16I	Month 3	100	19-Nov-99	290 BJ	100 U	500 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	110	100 U	100 U	100 U	100 U	1700	100 U
HN-1912	Month 3	1(2)	17-Nov-99	0.8 J	1 U	5 U	1 U	1 U	1 U	1	1 U	56 D	1 U	1 U	1 U	1 U	1 U	8	1 U	1	1 U
HN-50I	Month 3	1	17-Nov-99	2 BJ	1 U	5 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	4	1 U
HN-52I	Month 3	1(25)	17-Nov-99	1 J	1 U	5 U	1 U	0.7 J	5	0.9 J	1 U	4	4	1 U	0.5 J	1 U	41	0.8 J	2	530 D	1 U
HN-52D	Month 3	1	17-Nov-99	5 U	1 U	5 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
HN-55I	Month 1	10	20-Sep-99	16 U	10 U	50 U	10 U	9 J	10 U	10 U	10 U	25	10 U	10 U	6 J	10 U	20	10 U	10 U	500	10 U
HN-55I	Month 3	10(25)	19-Nov-99	120 U	25 U	120 U	25 U	18 DJ	25 U	25 U	25 U	15 DJ	25 U	25 U	25 U	25 U	24 DJ	25 U	25 U	970 D	25 U
HN-59I	Month 1	250	20-Sep-99	1200 U	250 U	1200 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	140 J	250 U	250 U	250 U	250 U	4800	250 U
OB-A2	Month 1	10	20-Sep-99	50 U	10 U	50 U	10 U	18	11	10 U	10 U	10 U	89	10 U	6 BJ	10 U	230	10 U	10 U	270	10 U
OB-A2	Month 3	10(50)	23-Nov-99	72 BDJ	50 U	50 U	50 U	32 DJ	50 U	50 U	50 U	50 U	50 U	50 U	72 D	50 U	85 D	50 U	50 U	930 D	50 U
WMA-26	Month 3	1	23-Nov-99	5 U	0.9 J	5 U	1 U	1 U	1 U	1 U	17	19	10	1 U	1 U	1 U	75	16	1 U	170	1 U
WW-1	Month 3	1	19-Nov-99	2 BJ	1 U	5 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1	1 U	1 U	27	1 U
Hydrogeologic Unit C-no samples were collected from this unit during this time period																					
Between																					
HN-15I	Month 3	1	19-Nov-99	2 BJ	1 U	5 U	1 U	1 U	1 U	1 U	1 U	1 U	0.7 J	1 U	1 U	1 U	1	1 U	1 U	15	1 U
HN-19I1	Month 3	1	17-Nov-99	2 J	1 U	5 U	1 U	1 U	0.6 J	1	1 U	6	1	1 U	1 U	1 U	2	2	1 U	30	1 U

* Indicates a diluted result

Notes: Month 1(9/15/99 to 9/20/99); Month 2 (10/14/99 to 10/15/99); Month 3 (11/16/99 to 11/18/99)
Only detected analytes are shown on this table
All results are in ppb

Qualifiers: U=Analyte was not detected at the stated quantitation limit.
J=Analyte results is “estimated” because either the analyte was detected at a level below the quantitation limit, or for other reasons.
B=Analyte was also detected in the associated method blank as well as in the sample
D=The initial analysis for this compound exceeded the calibration range so this result is from the secondary dilution indicated.

TABLE 7

HISTORICAL ANALYTICAL RESULTS FOR SELECTED MONITORING WELLS
NAWC WARMINSTER, PENNSYLVANIA
PAGE 1 OF 2

Well ID:	SAMPLE DATE:	CHLOROFORM	1,1,1-TCA	1,1,2-TCA	1,1-DCA	1,1-DCE	1,2-DCA	CIS-1,2-DCE	TRANS-1,2-DCE	CCl_4	PCE	TCE	VC
WW-1	12/23/97	ND	ND	ND	ND	ND	ND	0.6 J	ND	ND	2	31	ND
WW-1	12/23/97	ND	ND	ND	ND	ND	ND	ND	ND	ND	2	21	ND
WW-1(Day-3)	6/28/99	0.7 J	ND	ND	ND	ND	ND	3	ND	2	6	71	ND
WW-1(Month 3)	11/19/99	ND	ND	ND	ND	ND	ND	ND	ND	ND	1	27	ND
HN-11I	1/9/95	ND	ND	ND	ND	ND	ND	ND	ND	1000	ND	60000	ND
HN-11IDUP	1/9/95	ND	ND	ND	ND	ND	ND	ND	ND	1000	ND	61000	ND
HN-11I	4/5/95	ND	ND	ND	ND	ND	ND	ND	ND	670	ND	29000	ND
HN-11IDUP	4/5/95	ND	ND	ND	ND	ND	ND	ND	ND	600	ND	28000	ND
HN-11I	7/10/95	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	72000	ND
HN-11I	9/25/95	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	52000	ND
HN-11I	12/22/95	ND	ND	ND	ND	ND	ND	ND	ND	310	ND	15000	ND
HN-11IDUP	12/22/95	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	14000	ND
H-11I	4/9/96	ND	ND	70	ND	ND	9 J	ND	ND	240	ND	9800	ND
HN-11I	12/23/97	40 J	0.7 J	67 J	1 J	11 J	ND	7 J	ND	990 J	42 J	32000	0.9 J
HN-11I	7/1/98	12	ND	21	ND	4	ND	4	ND	130	13	10000	ND
HN-11IDUP	7/1/98	13	ND	22	ND	4	ND	4	ND	170	13	12000	ND
HN-11I	12/16/98	ND	ND	ND	ND	ND	ND	ND	ND	1900	ND	7600	ND
HN-11I(Day-3)	6/29/99	12	ND	18	1	4	0.9 J	3	ND	250 D	16	8500 BD	ND
HN-11I(Month 1)	9/15/99	ND	ND	ND	ND	ND	ND	ND	ND	1800 J	ND	92000	ND
HN-11I(Month 3)	11/23/99	ND	ND	ND	ND	ND	ND	ND	ND	1400 J	ND	83000	ND
HN-16I	10/7/94	ND	ND	ND	ND	ND	ND		ND	140	ND	7300	ND
HN-16I	4/5/95	ND	ND	ND	ND	ND	ND	ND	ND	59	33	3900	ND
HN-16I	7/13/95	ND	ND	ND	ND	ND	ND	ND	ND	88	ND	4900	ND
HN-16I	9/28/95	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	5700	ND
HN-16I	12/26/95	ND	ND	ND	ND	ND	ND	DN	ND	ND	ND	4500	ND
HN-16I	4/4/96	ND	ND	8 J	ND	7 J	ND	15	ND	85	ND	4100	ND
HN-16I	9/9/97	12	ND	11	0.8 J	5	ND	15	ND	110	68 J	5200	ND
HN-16I	12/5/97	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2300	ND
HN-16I	5/25/98	ND	ND	5	ND	1	ND	9	ND	58	49	2900	ND
HN-16I	12/18/98	ND	ND	ND	ND	ND	ND	ND	ND	90	60	4900 J	ND
HN-16IDUP	12/18/98	ND	ND	ND	ND	ND	ND	ND	ND	91	62	4800 J	ND
HN-16I(Day-3)	6/29/99	11	ND	9	0.7 J	2	0.7 J	13	ND	91	65	3500 BD	ND
HN-16I(Month 1)	9/15/99	ND	ND	ND	ND	ND	ND	ND	ND	ND	25 J	1800	ND
HN-16I(Month 3)	11/23/99	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1700	ND
HN-52I	8/1/95	3 J	70	ND	95	69	ND			ND	120	460	ND
HN-52I	9/28/95	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	760	ND
HN-52I	12/11/97	2	ND	ND	ND	2	ND	2	ND	ND	12	300	ND
HN-52I	6/29/98	3	ND	1	ND	3	ND	3	ND	ND	32	630	ND
HN-52I	12/16/98	5	0.8	2	1	5	ND	4	ND	2	44	860	ND
HN-52I(Day-3)	6/28/99	7 J	ND	ND	ND	ND	ND	ND	ND	ND	45	920	ND

TABLE 7

HISTORICAL ANALYTICAL RESULTS FOR SELECTED MONITORING WELLS
NAWC WARMINSTER, PENNSYLVANIA

Well ID:	SAMPLE DATE:	CHLOROFORM	1,1,1-TCA	1,1,2-TCA	1,1-DCA	1,1-DCE	1,2-DCA	CIS-1,2-DCE	TRANS-1,2-DCE	CCl_4	PCE	TCE	VC
HN-52I(Month-3)	11/17/99	5	0.8 J	2	0.9 J	4	ND	4	ND	0.7 J	41	530 D	ND
HN-52S	8/1/95	5 J	700	2 J	150	200	ND			ND	210	780	ND
HN-52S	9/28/95	ND	520	ND	180	170	ND	ND	ND	64	180	320	ND
HN-52S	12/11/97	ND	340	ND	190	210	ND	ND	ND	ND	420	140	ND
HN-52S	6/29/98	ND	1000	ND	140	290	ND	660	ND	ND	3200	540	ND
HN-52S	12/15/98	0.8	210	ND	200	200	ND	75	ND	ND	470	180	ND
HN-52S(Day-3)	6/28/99	ND	480 D	ND	200	240 D	0.9 J	360 D	ND	ND	2100 D	390 D	ND
HN-52S(Month 3)	11/17/99	ND	780	ND	180	350	ND	490	ND	ND	4800	1000	ND
HN-55I	9/7/95	7	ND	3	ND	ND	ND	4	ND	46 J	77 J	2200	ND
HN-55IDUP	9/7/95	6	ND	4	ND	ND	ND	4	ND	44 J	72 J	1900	ND
HN-55I	12/21/95	ND	ND	ND	ND	ND	ND	ND	ND	12	32	260	ND
HN-55I	4/9/96	7	ND	ND	ND	2	0.7 J	5	ND	19	ND	420	ND
HN-55I	12/11/97	25	ND	25	ND	ND	ND	ND	ND	220	160	7800	ND
HN-55I	12/4/98	15	ND	10	0.7	2	0.8	7	ND	210	280	2100	ND
HN-55I(Day-3)	6/29/99	9	ND	1	0.9 J	1	0.8 J	5	ND	53	180 D	370 D	ND
HN-55I(Month 1)	9/20/99	ND	ND	ND	ND	25	ND	ND	ND	9 J	20	500	ND
HN-55I(Month 3)	11/19/99	ND	ND	ND	ND	15 DJ	ND	ND	ND	18 DJ	24 DJ	970 D	ND
HN-59I	12/18/97	ND	ND	ND	ND	ND	ND	ND	ND	370	150 J	15000	ND
HN-59IDUP	12/18/97	25	0.8 J	29 J	0.9 J	6	1	13	ND	420 J	110 J	15000	ND
HN-59I	12/18/98	ND	ND	ND	ND	ND	ND	ND	ND	220	94	12000 J	ND
HN-59I(Day-3)	6/29/99	16	ND	14	ND	2	ND	7	ND	130	93	5700 D	ND
HN-59I(Month 1)	11/20/99	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4800	ND
Federal MCL		80	200	3	–	7	5	70	100	5	5	5	2

– denotes that a Federal MCL does not exist for this compund.
ND - Not Detected
Federal MCL - EPA Office of Water; Drinking Water Regulations and Health Advisories, October 1996.
Notes: Blank space means the sample was not analyzed for this compound during this sampling round.
All results reported in ug/L.
Bolded and shaded values indicate that the sample result is in excess of the Federal MCL.

TABLE 8

TCE CONCENTRATION TRENDS SINCE EXTRACTION SYSTEM STARTUP
NAWC WARMINSTER, PENNSYLVANIA
PAGE 1 OF 2

Well	Day –3 TCE Level (ug/L)	Day+28 (Month 1) TCE Level (ug/L))	Month 2 TCE Level (ug/L)	Month 3 TCE Level (ug/L)
EXTRACTION WELLS				
EW-A1	930B	1100	780	470
EW-A2	2300BD	2300	940	850
EW-A3	4000BD	6800	3100	3900
EW-A4	8800B	39000	27000	28000
EW-A5	9600BD	2700	NS	22000D
EW-A6	240000BD	120000	NS	150000
EW-A7	150000B	280000	200000	170000
EW-A8	180D	390	810	400
EW-A9	46000D	47000	NS	110000D
EW-A10	72000BD	48000	49000	27000
EW-A11	62	24	26	28
EW-A12	70	200	400	2600D
EW-A13	3B	32	33	42
EW-A15	13	12	10	13
HYDROGEOLOGIC UNIT A				
HN-15S	780BD	20	NS	NS
HN-19S	ND	NS	NS	ND
HN-50S	NS	350	NS	290
HN-52S	390D	NS	NS	1000
HN-55S	120B	NS	NS	120
HN-59S	NS	NS	NS	420D
SMC-01	3B	NS	NS	0.6J

TABLE 8

TCE CONCENTRATION TRENDS SINCE EXTRACTION SYSTEM STARTUP
NAWC WARMINSTER, PENNSYLVANIA
PAGE 2 OF 2

Well	Day –3 TCE Level (ug/L)	Day+28 (Month 1) TCE Level (ug/L))	Month 2 TCE Level (ug/L)	Month 3 TCE Level (ug/L)
HYDROGEOLOGIC UNIT B				
HN-11S	570BD	NS	NS	3300
HN-12S	61B	NS	NS	88
HN-13S	11	NS	NS	11
HN-11I	8500BD	92000	NS	83000
HN-14I	7300D	1200	NS	1500
HN-16I	3500BD	1800	NS	1700
HN-52I	920	NS	NS	530D
HN-52D	26	NS	NS	ND
HN-55I	370D	500	NS	970
HN-59I	5700D	4800	NS	NS
OB-A2	1200D	270	NS	930
WTMA-26	160	NS	NS	170
WW1	71	NS	NS	27
OTHER WELLS				
HN-15I	8B	NS	NS	15
HN-19I1	3	NS	NS	30

Notes:

B: Analyte was also detected in associated method blank.

D: The initial analysis exceeded the calibration range, so this result is from the secondary dilution.

J: Analyte result is estimated

ND: Not detected NS:

NS: Not sampled

TABLE 9

SELECTION OF CONTAMINANTS OF POTENTIAL CONCERN
FOR 1999 PERFORMANCE MONITORING DATA
NAWC WARMINSTER, PENNSYLVANIA
PAGE 1 OF 2

WELL NAME	DAYS OF SYSTEM OPERATION	DATE SAMPLE COLLECTED	BENZENE	BROMODICHLORO METHANE	CARBON DISULFIDE	CARBON TETRACHLORIDE	CHLOROFORM	1,1-DICHLORO ETHANE	1,2-DICHLORO ETHANE	1,1-DICHLORO ETHENE	CIS-1,2-DICHLORO ETHENE	TRANS-1,2-DICHLOROETHENE	TETRACHLORO ETHENE (PCE)	1,1,1-TRICHLORO ETHANE	1,1,2-TRICHLORO ETHANE	TRICHLORO ETHENE (TCE)	VINYL-CHLORIDE	CONTAMINANTS OF POTENTIAL CONCERN[3]
Extraction Wells																		
EW-A1	Month 3	15-Nov-99	ND	ND	ND	8	ND	ND	ND	ND	ND	ND	**7**	ND	ND	**470**	ND	CCl_4, PCE, TCE
EW-A10	Month 3	16-Nov-99	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**27000**	ND	
EW-A11	Month 3	17-Nov-99	ND	ND	ND	**13**	3	ND	ND	4	ND	ND	**120**	ND	ND	**28**	ND	
EW-A12	Month 3	15-Nov-99	ND	ND	ND	**140**	10	ND	ND	ND	22	ND	**150**	ND	3	**2600**	ND	
EW-A13	Month 3	17-Nov-99	ND	ND	ND	**39**	6	ND	ND	3	5	ND	**250**	ND	ND	**42**	ND	
EW-A15	Month 3	15-Nov-99	ND	ND	ND	ND	1	0.8	ND	ND	4	ND	**17**	ND	ND	**13**	ND	
EW-A2	Month 3	15-Nov-99	ND	ND	ND	**17**	ND	ND	ND	ND	ND	ND	**16**	ND	ND	**850**	ND	
EW-A3	Month 3	15-Nov-99	ND	ND	ND	**97**	ND	ND	ND	ND	ND	ND	**70**	ND	ND	**3900**	ND	
EW-A4	Month 3	15-Nov-99	ND	ND	ND	**590**	ND	ND	ND	ND	ND	ND	**130**	ND	ND	**28000**	ND	
EW-A5	Month 3	23-Nov-99	ND	ND	**830**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**22000**	ND	
EW-A6	Month 2	14-Oct-99	ND	ND	ND	**3800**	ND	ND	ND	ND	ND	ND	**510**	ND	ND	**150000**	ND	
EW-A7	Month 3	15-Nov-99	ND	ND	ND	**5500**	ND	ND	ND	ND	ND	ND	ND	ND	ND	**170000**	ND	
EW-A8	Month 3	23-Nov-99	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**400**	ND	
EW-A9	Month 3	19-Nov-99	ND	ND	ND	**3000**	ND	ND	ND	ND	ND	ND	ND	ND	ND	**110000**	ND	
Range			- -	- -	830	8 - 5500	1 - 10	0.8	- -	3 - 4	4 - 22	- -	7 - 510	- -	3	13 - 170000	- -	
Federal MCL[1]			5	80	- -	5	80	- -	5	7	70	100	5	200	3	5	2	
Frequency of Detection			0/14	0/14	1/14	10/14	4/14	1/14	0/14	2/14	3/14	0/14	9/14	0/14	1/14	14/14	0/14	
Average[2]			NC	NC	830	1320	5	0.8	NC	3.5	10.3	NC	141	NC	3	36807	NC	
Location of Maximum			- -	- -	EW-A5	EW-A7	EW-A12	EW-A15	- -	EW-A11	EW-A12	- -	EW-A6	- -	EW-A12	EW-A7	- -	
Hydrogeologic Unit A																		
HN-15S	Day -3	28-Jun-99	ND	ND	ND	3	3	ND	1	2	**230**	ND	**16**	ND	1	**780**	**8**	1,1-DCE, CIS-1,2-DCE, PCE, TCE, VINYL CHLORIDE, 1,1,1-TCA
HN-65I1	Day-3	28-Jun-99	ND	ND	ND	ND	ND	23	ND	**30**	18	ND	**99**	27	ND	**100**	ND	
HN-66S	Day-3	28-Jun-99	ND	ND	ND	ND	ND	ND	ND	ND	5	ND	**9**	ND	ND	5	ND	
HN-19S	Month 3	17-Nov-99	ND	ND	ND	ND	ND	2	ND	6	ND	ND	ND	3	ND	ND	ND	
HN-50S	Month 3	17-Nov-99	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**290**	ND	
HN-52S	Month 3	17-Nov-99	ND	ND	ND	ND	ND	180	ND	**350**	**490**	ND	**4800**	**780**	ND	1000	ND	
HN-55S	Month 3	19-Nov-99	ND	ND	ND	3	2	ND	ND	ND	ND	ND	0.6	ND	ND	**120**	ND	
HN-59S	Month 3	23-Nov-99	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**420**	ND	
SMC-01	Month 3	17-Nov-99	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3	ND	ND	0.6	ND	
Range			- -	- -	- -	3	2 - 3	2 - 180	1	2 - 350	5 - 490	- -	0/6 - 4800	3 - 780	1	0.6 - 1000	8	
Federal MCL[1]			5	80	- -	5	80	- -	5	7	70	100	5	200	3	5	2	
Frequency of Detection			0/9	0/9	0/9	2/9	2/9	3/9	1/9	4/9	4/9	0/9	6/9	3/9	1/9	8/9	1/9	
Average[2]			NC	ND	NC	3	2.5	68.3	1	97	186	NC	821	270	1	339	8	
Location of Maximum			- -	- -	- -	HN-15S/ HN-55S	HN-15S	HN-52S	HN-15S	HN-52S	HN-52S	- -	HN-52S	HN-52S	HN-15S	HN-52S	HN-15S	

TABLE 9

SELECTION OF CONTAMINANTS OF POTENTIAL CONCERN
FOR 1999 PERFORMANCE MONITORING DATA
NAWC WARMINSTER, PENNSYLVANIA

WELL NAME	DAYS OF SYSTEM OPERATION	DATE SAMPLE COLLECTED	BENZENE	BROMODICHLORO METHANE	CARBON DISULFIDE	CARBON TETRACHLORIDE	CHLOROFORM	1,1-DICHLORO ETHANE	1,2-DICHLORO ETHANE	1,1-DICHLORO ETHENE	CIS-1,2-DICHLORO ETHENE	TRANS-1,2-DICHLOROETHENE	TETRACHLORO ETHENE (PCE)	1,1-TRICHLORO ETHANE	1,1,2-TRICHLORO ETHANE	TRICHLORO ETHENE (TCE)	VINYL-CHLORIDE	CONTAMINANTS OF POTENTIAL CONCERN[3]
Hydrogeologic Unit B																		
HN-11S	Month 3	23-Nov-99	ND	27	ND	**23**	ND	ND	ND	ND	ND	ND	ND	ND	ND	3300	ND	CCl_4, 1,2-DCA, 1,1-DCE, CIS-1,2-DCE, PCE, 1,1,2-TCA, TCE
HN-12S	Month 3	17-Nov-99	ND	ND	ND	0.7	15	2	ND	ND	**130**	2	**140**	4	ND	**88**	0.6	
HN-13S	Month 3	17-Nov-99	ND	ND	ND	ND	ND	2	ND	1	1	1	**4**	0.9	ND	**11**	ND	
HN-11I	Month 3	23-Nov-99	ND	ND	ND	**1400**	ND	ND	ND	ND	ND	ND	ND	ND	ND	**83000**	ND	
HN-14I	Month 3	19-Nov-99	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**1500**	ND	
HN-16I	Month 3	19-Nov-99	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**ND**	**ND**	ND	**1700**	ND	
HN-19I2	Month 3	17-Nov-99	ND	ND	ND	ND	ND	1	ND	**56**	ND	ND	ND	8	ND	**1**	ND	
HN-50I	Month 3	17-Nov-99	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**4**	ND	
HN-52I	Month 3	17-Nov-99	ND	ND	ND	0.7	5	0.9	ND	4	4	ND	**41**	0.8	2	**530**	ND	
HN-52D	Month 3	17-Nov-99	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
HN-55I	Month 3	19-Nov-99	ND	ND	ND	**18**	ND	ND	ND	15	ND	ND	24	ND	ND	**970**	ND	
HN-59I	Day -3	29-Jun-99	0.6	ND	ND	**130**	16	ND	ND	2	7	ND	**93**	ND	14	**5700**	ND	
OB-A2	Month 3	23-Nov-99	ND	ND	ND	**32**	ND	ND	ND	ND	ND	ND	**85**	ND	ND	**930**	ND	
WMA-26	Month 3	23-Nov-99	ND	0.9	ND	ND	ND	ND	**17**	**19**	10	ND	**75**	16	ND	**170**	ND	
WW-1	Month 3	19-Nov-99	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1	ND	ND	27	ND	
		Range	0.6	0.9 - 27	- -	0.7 - 1400	5 - 16	0.9 - 2	17	1 - 56	1 - 130	1 - 2	1 - 140	0.8 - 16	2 - 14	1 - 83000	0.6	
		Federal MCL[1]	5	80	- -	5	80	- -	5	7	70	100	5	200	3	5	2	
		Frequency of Detection	1/15	2/15	0/15	7/15	3/15	4/15	1/15	6/15	5/15	2/15	8/15	5/15	2/15	14/15	1/15	
		Average[2]	0.6	14	NC	229	12	1.5	17	16.2	30.4	1.5	57.9	5.9	8	6995	0.6	
		Location of Maximum	HN-59I	HN-11S	- -	HN-11I	HN-59I	HN-12S/ HN-13S	WMA-26	HN-1912	HN-12S	HN-12S	HN-12S	WMA-26	HN-59I	HN-11I	HN-12S	
Hydrogeologic Unit C																		
HN-50D	Day +21	10-Sep-99	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**100**	ND	**TCE**

MCL - Maximum Contaminant Level.
- - denotes that no Federal MCL Is available for this compound or that a value could not be determined because the compound was not positively detected.
1 -EPA Office of Water; Drinking Water Regulations and Health Advisories, October 1996.
2 - Calculation of average using positive results only.
3 - Chemical which have maximum detected concentrations in excess of Federal MCLs are selected a Chemicals of Potential Concern.
ND - Not detected
NC - Not calculated because this compound was not positively detected.
Bolded values exceed MCLs.
CCI4 - Carbon tetrachloride
1,1 -DCA - 1,1-Dichloroethane
1,1-Dichloroethene
cis-1,2-Dichloroethene
PCE - Tetrachloroethene
1,1,1-TCA - 1,1,1-Trichloroethane
1,1,2-TCA - 1,1,2-Trichloroethane
TCE - Trichloroethene

TABLE 10

SELECTION OF CHEMICALS OF POTENTIAL CONCERN FOR HYDROGEOLOGIC UNIT A
DEC 1997/JAN 1998
NAWC WARMINSTER, PENNSYLVANIA

Compound	Frequency of Detection[1]	Range of Positive Details	Location of Maximum	Average of Positive Results[2]	Average of All Results[3]	Federal MCL[4]	Background Concentration	Selected as a COPC (Yes or No)[7]
VOLATILES (µg/L)								
1,1,1-Trichloroethane	6/14	0.6 - 340	W-HN-52S	94	41	200	NC	Yes
1,1,2-Trichloroethane	1/14	0.7	W-HN-14S	0.7	2	5	NC	No
1,1-Dichloroethane	6/14	0.6 - 190	W-HN-52S	36	17	- -	NC	No
1,1-Dichloroethene	6/14	0.6 - 210	W-HN-52S	44	20	7	NC	Yes
1,2-Dichloroethane	1/14	1	W-HN-59S	1	2	5	NC	No
Carbon Tetrachloride	6/14	3 - 12	W-SMC-01	6	4	5	NC	Yes
Chloroform	2/14	2	W-HN-14S	2	3	80	NC	No
Tetrachloroethene	11/14	1 - 420	W-HN-52S	55	43	5	NC	Yes
Trichloroethene	13/14	0.7 - 410	W-HN-11S	155	144	5	NC	Yes
cis-1,2-dichloroethene	7/14	0.9 - 7	W-HN-15S	2	3	70	NC	No
INORGANICS (µG/L)								
Antimony	1/4	4	W-HN-14S	4	1.6	6	ND	No
Barium	2/4	40.7 - 54.1	W-HN-11S	47.4	29	2000	628	No
Calcium	4/4	27600 - 64400	W-HN-59S	42700	42700	- -	31800	No
Chromium	4/4	7.5 - 72.1	W-HN-55S	30.3	30.3	100	5.5	No
Iron	1/4	29500	W-HN-11S	29500	7400	300[5]	4850	Yes
Lead	1/4	5.7	W-HN-11S	6	2.03	15[6]	13.6	No
Magnesium	4/4	10700 - 22900	W-HN-59S	15700	15750	- -	11300	No
Manganese	1/4	154	W-HN-11S	154	44.1	50[5]	422	No
Mercury	1/4	0.56	W-HN-11S	0.56	0.19	2	0.17	No
Nickel	2/4	7.8 - 9.8	W-HN-11S	8.8	6.0	100	ND	No
Potassium	3/4	3490 - 3720	W-HM-55S	2900	2300	- -	2150	No
Silver	2/4	2 - 3	W-HN-14S	2.5	1.6	100	ND	No
Sodium	4/4	12200 - 45700	W-HN-11S	27800	27800	- -	14700	No

COPC - Chemical of Potential Concern.

Associated Samples
W-HN-11S 12/23/97
W-HN-11X 12/23/97
W-HN-14S 12/17/97
W-HN-15S 12/10/97
W-HN-16O 12/05/97
W-HN-16S 12/05/97
W-HN-19S 12/08/97
W-HN-50S 12/08/97
W-HN-50S-DUP 12/08/97
W-HN-52S 12/11/97
W-HN-55S 12/11/97
W-HN-59S 12/23/97
W-HN-65I1 12/04/97
W-SMC-01 12/22/97

MCL - Maximum Contaminant Level.
- - denotes that no Federal MCL is available for this compound.
1 - Duplicate samples are treated as separate samples.
2 - Calculation of average using positive results only.
3 - Calculation of average also considers one-half the nondetected values.
4 - EPA Office of Water; Drinking Water Regulations and Health Advisories, October 1996.
5 - Value is the secondary MCL
6 - The value is an action level.
7 - If the maximum detected chemical concentration exceeds the Federal MCL and the background concentration, the chemical is selected as a COPC.
Bolded Compounds were selected as COPCs.
NC - Not Calculated
ND - Not Detected

TABLE 11

SELECTION OF CHEMICALS OF POTENTIAL CONCERN FOR HYDROGEOLOGIC UNIT B
DEC 1997/JAN 1998
NAWC WARMINSTER, PENNSYLVANIA
PAGE 1 OF 2

Compound	Frequency of Detection[1]	Range of Positive Details	Location of Maximum	Average of Positive Results[2]	Average of All Results[3]	Federal MCL[4]	Background Concentration	Selected as a COPC (Yes or No)[6]
VOLATILES (µG/L)								
1,1,1-Trichloroethane	11/26	0.7 - 24	W-OS-757	3	9	200	NC	No
1,1,2-Trichloroethane	4/26	4 - 67	W-HN-11I	31	12	5	NC	Yes
1,1-Dichloroethane	15/26	0.4 - 19	W-OS-757	2	9	- -	NC	No
1,1-Dichloroethene	17/26	0.5 - 22	W-OS-757	4	10	7	NC	Yes
1,2-Dichloroethane	4/26	0.7 - 2	W-MW-E	1	8	5	NC	No
Acetone	1/3	16	W-OS-757	16	140	- -	NC	No
Benzene	2/26	1 - 10	W-HN-11I	6	8	5	NC	Yes
Carbon Disulfide	1/26	2	W-HN-11I	2	8	- -	NC	No
Carbon Tetrachloride	12/26	1 - 990	W-HN-11I	174	83	5	NC	Yes
Chloroform	7/26	2 - 40	W-HN-11I	14	12	80	NC	No
Ethylbenzene	1/26	4	W-HN-11I	4	8	700	NC	No
Tetrachloroethene	23/26	0.8 - 160	W-HN-55I	49	45	5	NC	Yes
Toluene	1/26	16	W-HN-11I	16	8	1000	NC	No
Trans-1,2-dichloroethene	1/26	0.6	W-SMP-02	0.6	8	100	NC	No
Trichloroethene	25/26	0.6 - 32000	W-HN-11I	3040	2920	5	NC	Yes
Vinyl Chloride	3/26	0.9 - 4	W-SMP-02	2	8	2	NC	Yes
Xylenes, Total	1/26	9	W-HN-11I	9	17	10000	NC	No
cis-1,2-dichloroethene	15/26	0.6 - 72	W-HN-12S	17	17	70	NC	Yes
INORGANICS (µg/L)								
Aluminum	1/4	479	W-HN-55I	479	141	50-200[5]	8220	NO
Barium	3/4	83.2 - 112	W-HN-14I	94.2	84.3	2000	628	No
Calcium	4/4	63100 - 69300	W-HN-59I	65200	65200	- -	31800	No
Chromium	4/4	12.2 - 43.9	W-HN-14I	21.9	21.9	100	5.5	No
Cyanide	1/4	6	W-HN-14I	6	3.4	200	ND	No
Iron	2/4	291 - 405	W-HN-55I	348	190	300[5]	48520	Yes
Magnesium	4/4	18100 - 21100	W-HN-14I	19500	19500	- -	11300	No
Manganese	1/4	201	W-HN-55I	201	52.8	50[5]	442	NO
Nickel	1/4	18.7	W-HN-14I	18.7	7.0	100	ND	No
Potassium	4/4	1780 - 11100	W-HN-59I	6550	6550	- -	2150	No
Silver	2/4	1.9 - 2.2	W-HN-59I-D	2.05	1.3	100	ND	No
Sodium	4/4	16300 - 25900	W-HN-14I	21000	21000	- -	14700	No
Zinc	1/4	60.7	W-HN-14I	60.7	20.4	5000[5]	33.2	No

COPC - Chemical of Potential Concern.

TABLE 11

SELECTION OF CHEMICALS OF POTENTIAL CONCERN FOR HYDROGEOLOGIC UNIT B
DEC 1997/JAN 1998
NAWC WARMINSTER, PENNSYLVANIA

MCL - Maximum Contaminant Level.
- - denotes that no Federal MCL is available for this compound.
NC - Not Calculated
ND - Not Detected
1 - Duplicate samples are treated as separate samples.
2 - Calculation of average using positive results only.
3 -Calculation of average also considers one-half the nondetected values.
4 -EPA Office of Water; Drinking Water Regulations and Health Advisories, October 1996.
5 - Value is the secondary MCL
6 - If the maximum detected chemical concentration exceeds the Federal MCL and the background concentration, the chemical is selected as a COPC.
Bolded Compounds were selected as COPCs.
Associated Samples:

W-DG-12 12/22/97	W-HN-50I 12/08/97	W-MW-E 12/19/97
W-DG-13 12/22/97	W-HN-52D 12/12/97	W-MW-EE 12/19/97
W-DG-130 12/22/97	W-HN-52I 12/11/97	W-OS-757 12/17/97
W-HN-11I 12/23/97	W-HN-55I 12/11/97	W-SMP-02 12/19/97
W-HN-12S 12/23/97	W-HN-59I 12/18/97	W-WW-1 12/23/97
W-HN-13S 12/19/97	W-HN-59I-D 12/18/97	W-WW-10 12/23/97
W-HN-141 12/17/97	W-HN-65I2 12/04/97	
W-HN-16I 12/05/97	W-HOBEN 12/09/97	
W-HN-19I2 12/08/97	W-MW-02 12/18/97	
W-HN-22S 12/09/97	W-MW-D 12/22/97	

TABLE 12

SELECTION OF CHEMICALS OF POTENTIAL CONCERN FOR HYDROGEOLOGIC UNIT C
DEC 1997/JAN 1998
NAWC WARMINSTER, PENNSYLVANIA

Compound	Frequency of Detection[1]	Range of Positive Details	Location of Maximum	Average of Positive Results[2]	Average of All Results[3]	Federal MCL[4]	Background Concentration	Selected as a COPC (Yes or No)[5]
VOLATILES (µg/L)								
1,1-Dichloroethane	1/6	1	W-HN-16D	1	0.6	- -	NC	No
1,1-Dichloroethene	1/6	2	W-HN-16D	2	0.8	7	NC	No
Acetone	1/1	8	W-HN-50D	8	8	- -	NC	No
Tetrachloroethene	1/6	3	W-HN-22I	3	0.9	5	NC	No
Trichloroethene	4/6	0.5 - 4	W-HN-16D	2	2	5	NC	No
cis-1,2-dichloroethene	1/6	0.5	W-HN-16D	0.5	0.5	70	NC	No

Associated Samples:
W-HN-11D 12/18/97
W-HN-16D 12/05/97
W-HN-19D 12/08/97
W-HN-22I 12/09/97
W-HN-50D 12/09/97
W-HN-65D 12/04/97

COPC - Chemical of Potential Concern.
MCL - Maximum Contaminant Level.
- - denotes that no Federal MCL is available for this compound.
1 - Duplicate samples are treated as separate samples.
2 - Calculation of average using positive results only.
3 - Calculation of average also considers one-half the nondetected values.
4 - EPA Office of Water; Drinking Water Regulations and Health Advisories, October 1996.
5 - If the maximum detected chemical concentration exceeds the Federal MCL the chemical is selected as a COPC.
NC - Not Calculated

TABLE 13

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
WARMINSTER AREA A UNFILTERED GROUNDWATER
NAWC WARMINSTER, PENNSYLVANIA

CAS Number	Chemical	Minimum (1) Concentration	Minimum Qualifier	Maximum (1) Concentration	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Federal (3) MCL	COPC Flag	Rationale for (4) Contaminant Deletion or Selection
7440-38-2	Arsenic	2.7	J	5.9	J	ug/L	MW-HN16S	3/18	10-10	5.9	50	N	BSL
7440-47-3	Chromium	1.3	J	47.3		ug/L	MW-HN59-I	15/18	5-5	47.3	100	N	BSL
7439-89-6	Iron	12.3	J	21500		ug/L	MW-D	18/18	N/A	21500	300 smcl	Y	ASL
7440-28-0	Thallium (see Note)	4.2	J	5.6	J	ug/L	MW-E	2/18	10-10	5.6	2	Y	ASL

1 Minimum/maximum detected concentration.

2 N/A - Refer to supporting information for background discussion.
Background values derived from statistical analysis. Follow Regional guidance and provide supporting information.

3 USEPA October 1996. Drinking Water Regulations and Health Advisories.

4 Rationale Codes
Selection Reason:
- Infrequent Detection but Associated Historically (HIST)
- Frequent Detection (FD)
- Toxicity Information Available (TX)
- Above Screening Levels (ASL)

Deletion Reason:
- Infrequent Detection (IFD)
- Background Levels (BKG)
- No Toxicity Information (NTX)
- Essential Nutrient (NUT)
- Below Screening Level (BSL)

Definitions:
MCL - Maximum Contaminant Concentration
SMCL - Secondary Maximum Contaminant Concentration

J - Value considered estimate due to exceedance of technical quality control criteria

NOTE: Laboratory preparation blanks contained thallium up to 6 ug/l.

TABLE 14

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
WARMINSTER AREA A FILTERED GROUNDWATER
NAWC WARMINSTER, PENNSYLVANIA

Cas Number	Chemical	Minimum (1) Concentration	Minimum Qualifier	Maximum (1) Concentration	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Federal (3) MCL		COPC Flag	Rationale for (4) Contaminant Deletion or Selection
7440-39-3	Arsenic	29	J	371		ug/L	MW-HN11I-F	18/18	--	371	2000		N	ASL
7440-47-3	Chromium	4.4	J	45.4		ug/L	MW-HN59-I-F	10/18	5-5	45.4	100		N	ASL
7439-89-6	Iron	10.1	J	1320		ug/L	MW-D-F	10/18	100-100	1320	300	smcl	Y	ASL
7440-28-0	Thallium	4.8	J	4.8	J	ug/L	MW-HN13S-F	1/18	10-10	4.8	2		Y	ASL

1 Minimum/maximum detected concentration.

2 N/A - Refer to supporting information for background discussion.
Background values derived from statistical analysis. Follow Regional guidance and provide supporting information.

3 USEPA October 1996. Drinking Water Regulations and Health Advisories.

4 Rationale Codes
Selection Reason: Infrequent Detection but Associated Historically (HIST)
Frequent Detection (FD)
Toxicity Information Available (TX)
Above Screening Levels (ASL)
Deletion Reason: Infrequent Detection (IFD)
Background Levels (BKG)
No Toxicity Information (NTX)
Essential Nutrient (NUT)
Below Screening Level (BSL)

Definitions: MCL - Maximum Contaminant Concentration
SMCL - Secondary Maximum Contaminant Concentration

TABLE 15

6/20/00 10:52 AM

NAVAL AIR WARFARE CENTER WARMINSTER
Warminster, Pennsylvania
Area A Groundwater Focused Feasiblity Study
Alternative 2: Existing Extraction, Treatment, and Surface Discharge System; Institutional Controls; and Monitoring
Present Worth Analysis

Year	Capital Cost	Operation and Maintenance Cost	Annual Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$7,688			$7,688	1.000	$7,688
1		$362,540	$122,200	$484,740	0.935	$453,232
2		$362,540	$61,100	$423,640	0.873	$369,838
3		$362,540	$61,100	$423,640	0.816	$345,690
4		$362,540	$30,550	$393,090	0.763	$299,928
5		$362,540	$40,550	$403,090	0.713	$287,403
6		$362,540	$30,550	$393,090	0.666	$261,798
7		$362,540	$30,550	$393,090	0.623	$244,895
8		$362,540	$30,550	$393,090	0.582	$228,778
9		$362,540	$30,550	$393,090	0.544	$213,841
10		$362,540	$40,550	$403,090	0.508	$204,770
11		$362,540	$30,550	$393,090	0.475	$186,718
12		$362,540	$30,550	$393,090	0.444	$174,532
13		$362,540	$30,550	$393,090	0.415	$163,132
14		$362,540	$30,550	$393,090	0.388	$152,519
15		$362,540	$40,550	$403,090	0.362	$145,919
16		$362,540	$30,550	$393,090	0.339	$133,258
17		$362,540	$30,550	$393,090	0.317	$124,610
18		$362,540	$30,550	$393,090	0.296	$116,355
19		$362,540	$30,550	$393,090	0.277	$108,886
20		$362,540	$40,550	$403,090	0.258	$103,997
21		$362,540	$30,550	$393,090	0.242	$95,128
22		$362,540	$30,550	$393,090	0.226	$88,838
23		$362,540	$30,550	$393,090	0.211	$82,942
24		$362,540	$30,550	$393,090	0.197	$77,439
25		$362,540	$40,550	$403,090	0.184	$74,169
26		$362,540	$30,550	$393,090	0.172	$67,611
27		$362,540	$30,550	$393,090	0.161	$63,287
28		$362,540	$30,550	$393,090	0.150	$58,964
29		$362,540	$30,550	$393,090	0.141	$55,426
30		$362,540	$40,550	$403,090	0.131	$52,805
					TOTAL PRESENT WORTH	**$5,044,393**

TABLE 15

NAVAL AIR WARFARE CENTER WARMINSTER

Warminster, Pennsylvania
Area A Groundwater Focused Feasibility Study
Alternative 2: Existing Extraction, Treatment, and Surface Discharge System; Institutional Controls; and Monitoring
Capital Cost

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Total Cost Subcontract	Total Cost Material	Total Cost Labor	Total Cost Equipment	Total Direct Cost
1 INSTITUTIONAL CONTROLS											
1.2 Prepare Deed Restrictions	100	hr			$40.00		$0	$0	$4,000	$0	$4,000
Subtotal							$0	$0	$4,000	$0	$4,000
Local Area Adjustments							100.0%	100.0%	124.8%	124.8%	
Subtotal							$0	$0	$4,992	$0	$4.992
Overhead on Labor Cost @ 30%									$1,498		$1,498
G & A on Labor Cost @ 10%									$499		$499
G & A on Material Cost @ 10%								$0			$0
G & A on Subcontract Cost @ 10%							$0				$0
Total Direct Cost							$0	$0	$6,989	$0	$6,989
Indirects on Total Direct Labor Cost @ 0%									$0		$0
Profit on Total direct Cost @ 0%											$699
Subtotal 3											$7,688
Health & Safety Monitoring @ 0%											$0
Total Field Cost											$7,688
Contingency on Total Field Cost @ 0%											$0
Engineering on Total Field Cost @ 0%											$0
TOTAL COST											**$7,688**

TABLE 15

NAVAL AIR WARFARE CENTER WARMINSTER

Warminster, Pennsylvania

Area A Groundwater Focused Feasibility Study

Alternative 2: Existing Extraction, Treatment and Surface Discharge System; Institutional Controls; and Monitoring

Operation and Maintenance Costs per Year

	Item	Qty	Unit	Unit Cost	Subtotal Cost	Notes
YEARS 1 THROUGH 30						
1	Energy - Electric	819,000	kWh	$0.06	$49,140	
2	Maintenance, Labor & Supplies	1	ls	$236,000.00	$236,000	
3	Changeout/Regeneration of Spent Carbon	1	ls	$50,000.00	$50,000	
4	Sample/analysis influent/effluent from system	12	ea	$900.00	$10,800	2 per month, TSS, TCL VOCs, TCL SVOCs
5	Sample/analysis air stripper offgas from system	4	ea	$150.00	$600	1 per quarter, BTEX, chlorinated VOCs
6	Quarterly Reports	4	ea	$4,000.00	$16,000	
	Subtotal Cost for One Year Operation during years 1-30				$362,540	

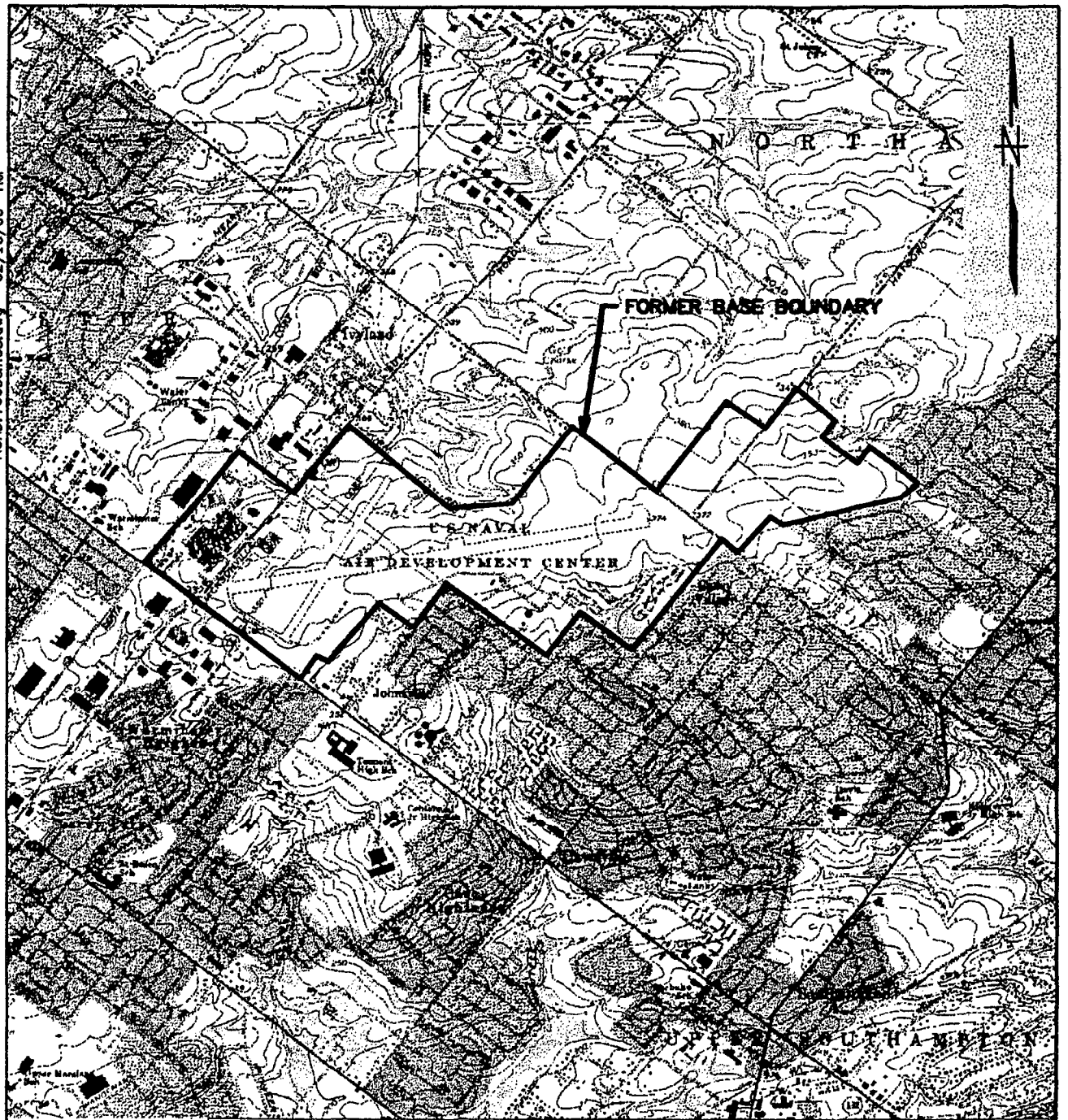
TABLE 15

NAVAL AIR WARFARE CENTER WARMINSTER
Warminster, Pennsylvania
Area A Groundwater Focused Feasibility Study
Alternative 2: Existing Extraction, Treatment, and Surface Discharge System; Institutional Controls; and Monitoring
Annual Sampling Cost

Item	Cost per Sampling Round Years 1 thru 5	Cost per Sampling Round Years 6 thru 30	Item Cost per 5 Years	Notes
Sampling	$17,200	$17,200		Collect groundwater samples, per sampling period, plus travel and living
Analysis/Water	$9,350	$9,350		Water samples, per sampling period, (including blanks and duplicates for each medium) TCL VOCs. Monitoring from 55 wells for 30 years
Report	$4,000	$4,000		Obtain lab, prepare sampling plan, document sampling events and results
Site Review	$0	$0	$10,000	Review of documents and data evaluation/recommendations
TOTALS	$30,550	$30,550	$10,000	

Sampling period: quarterly year 1
semi-annually years 2 and 3
annually years 4 thru 30

FIGURES



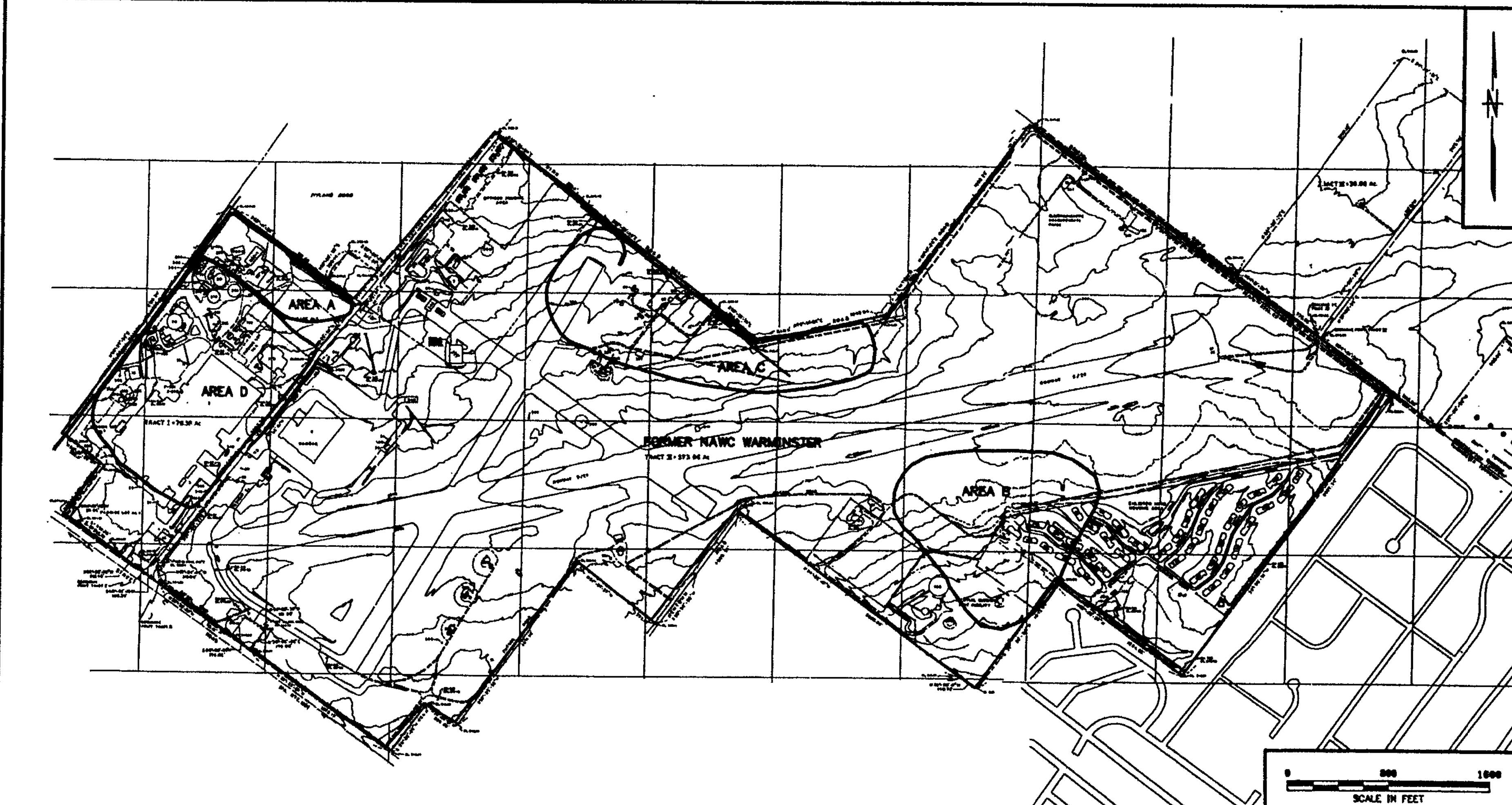
PENNSYLVANIA
QUADRANGLE LOCATION

SOURCE: U.S.G.S. 7.5 MINUTE HATBORO, PA QUADRANGLE 1966. PHOTOREVISED 1983.

DRAWN BY HJP DATE 2/18/00	Tetra Tech NUS, Inc.	CONTRACT NO. 7603	OWNER NO. 0290
CHECKED BY DATE		APPROVED BY DATE	
COST/SCHED—AREA	SITE LOCATION MAP FORMER NAWC, WARMINSTER, PA	APPROVED BY DATE	
SCALE AS NOTED		DRAWING NO. FIGURE 1	REV. 0

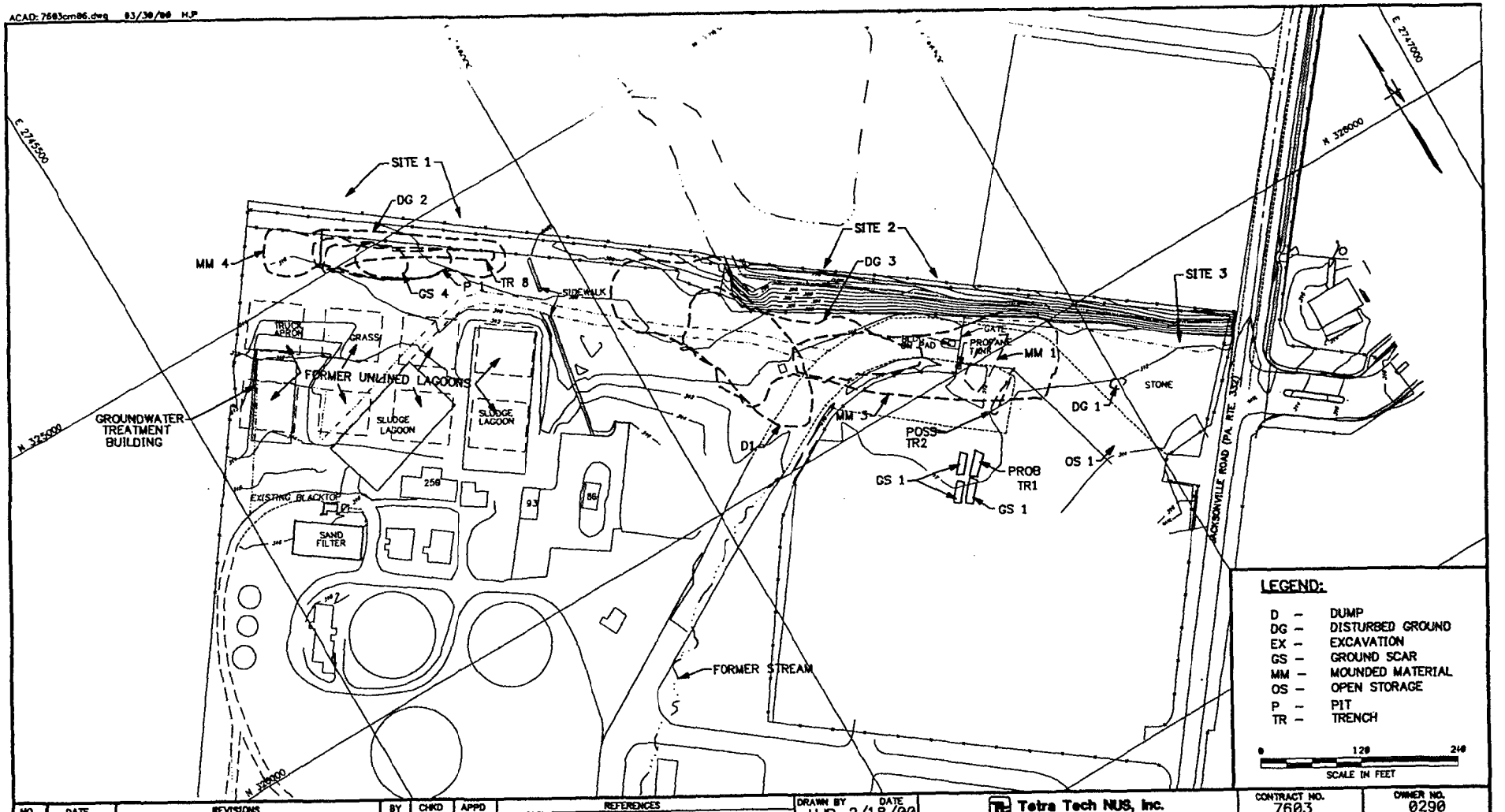
ACAD: 7603cm05.dwg 02/18/00 HJP

FORM CADD NO TTNUS_AV.DWG - REV 0 - 1/22/98



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES	DRAWN BY / DATE	Tetra Tech NUS, Inc.	CONTRACT NO.	OWNER NO.
							HJP 2/18/00		7603	0290
							CHECKED BY / DATE	AREAS OF INVESTIGATION FORMER NAWC, WARMINSTER, PA	APPROVED BY	DATE
							COST/SCHED-AREA		APPROVED BY	DATE
							SCALE AS NOTED		DRAWING NO. FIGURE 2	REV. 0

ACAD: 7603cm86.dwg 03/30/00 HJP



LEGEND:

- D – DUMP
- DG – DISTURBED GROUND
- EX – EXCAVATION
- GS – GROUND SCAR
- MM – MOUNDED MATERIAL
- OS – OPEN STORAGE
- P – PIT
- TR – TRENCH

0 120 240
SCALE IN FEET

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

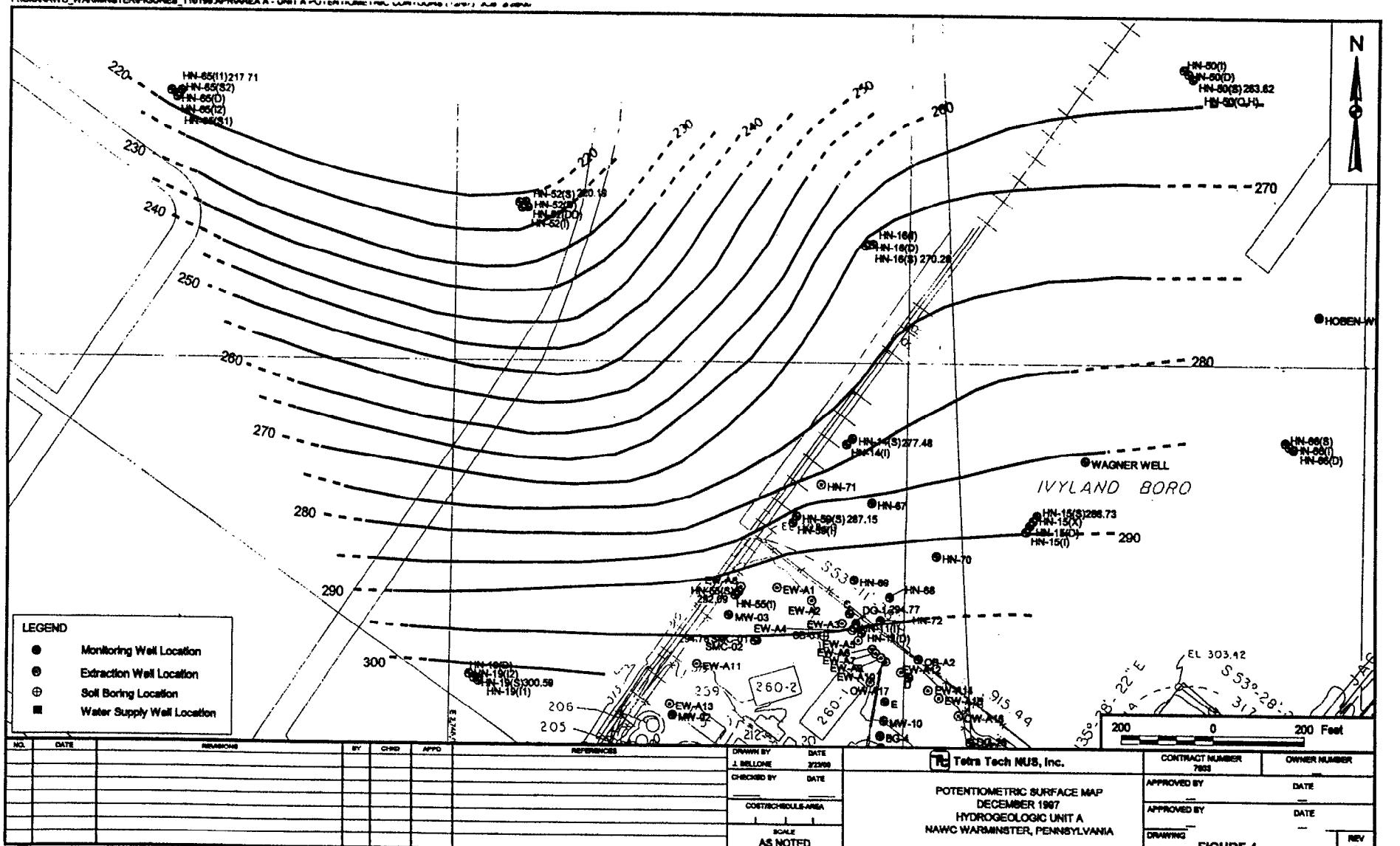
DRAWN BY HJP DATE 2/18/00
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

Tetra Tech NUS, Inc.

AREA A LAYOUT
FORMER NAWC, WARMINSTER, PA

CONTRACT NO. 7603
OWNER NO. 0290
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 3
REV. 0

FORM CADD NO. TtNUS_SHEET - REV 6 - 1/25/98



NO.	DATE	REMARKS	BY	CHKD	APPD

REFERENCES

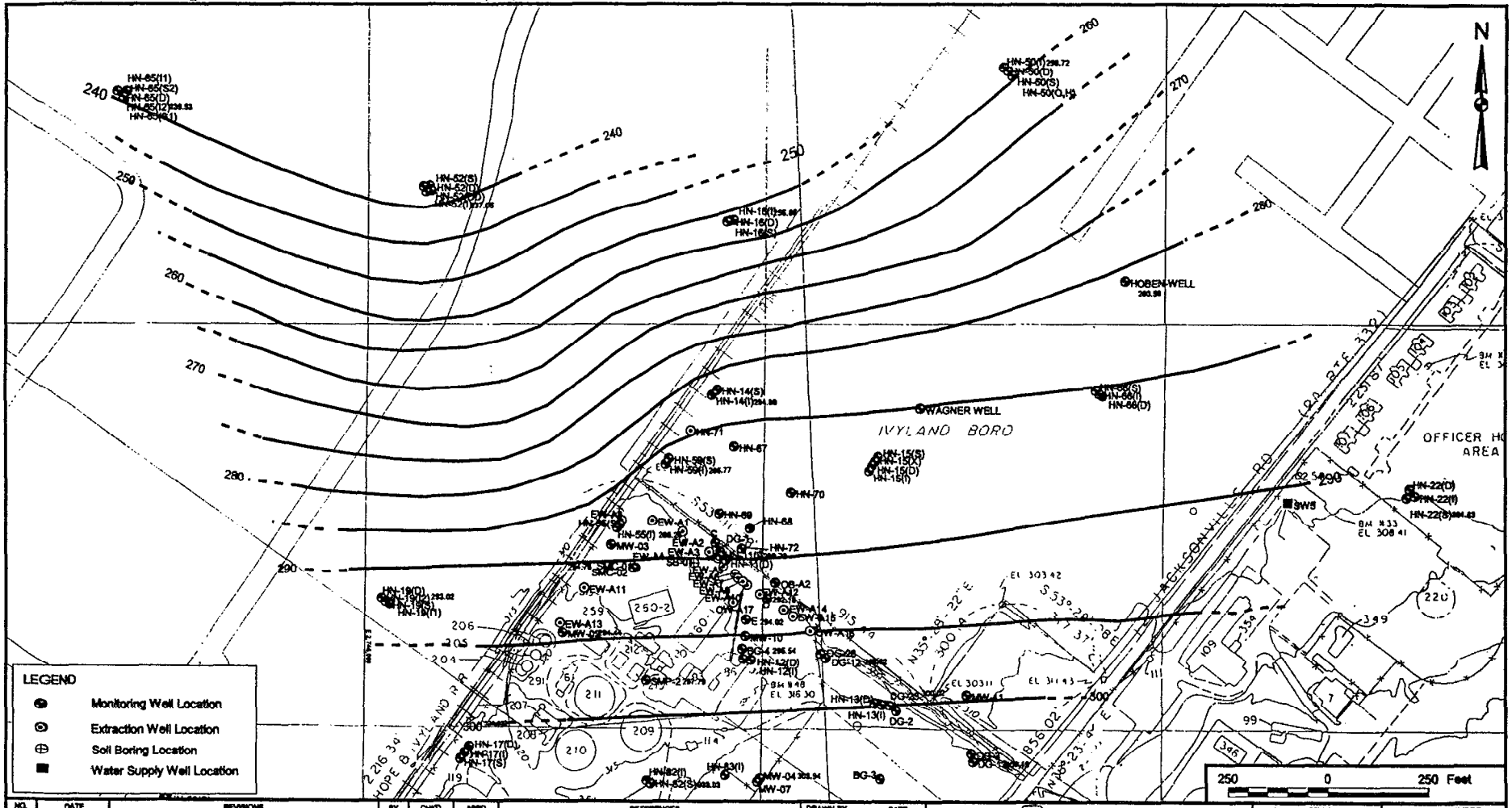
DRAWN BY	DATE
J. BELLONE	2/23/99
CHECKED BY	DATE
COST/SCHEDULE-AREA	
SCALE: AS NOTED	

Tetra Tech NUS, Inc.

POTENTIOMETRIC SURFACE MAP
DECEMBER 1997
HYDROGEOLOGIC UNIT A
NAWC WARMINSTER, PENNSYLVANIA

CONTRACT NUMBER	OWNER NUMBER
7603	
APPROVED BY	DATE
APPROVED BY	DATE
DRAWING	REV
FIGURE 4	0

P:\GIS\NAWC_WARMINSTER\FIGURES_110199\APR\AREA A - UNIT B POTENTIOMETRIC CONTOURS (12/97) JOB 2/23/00



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

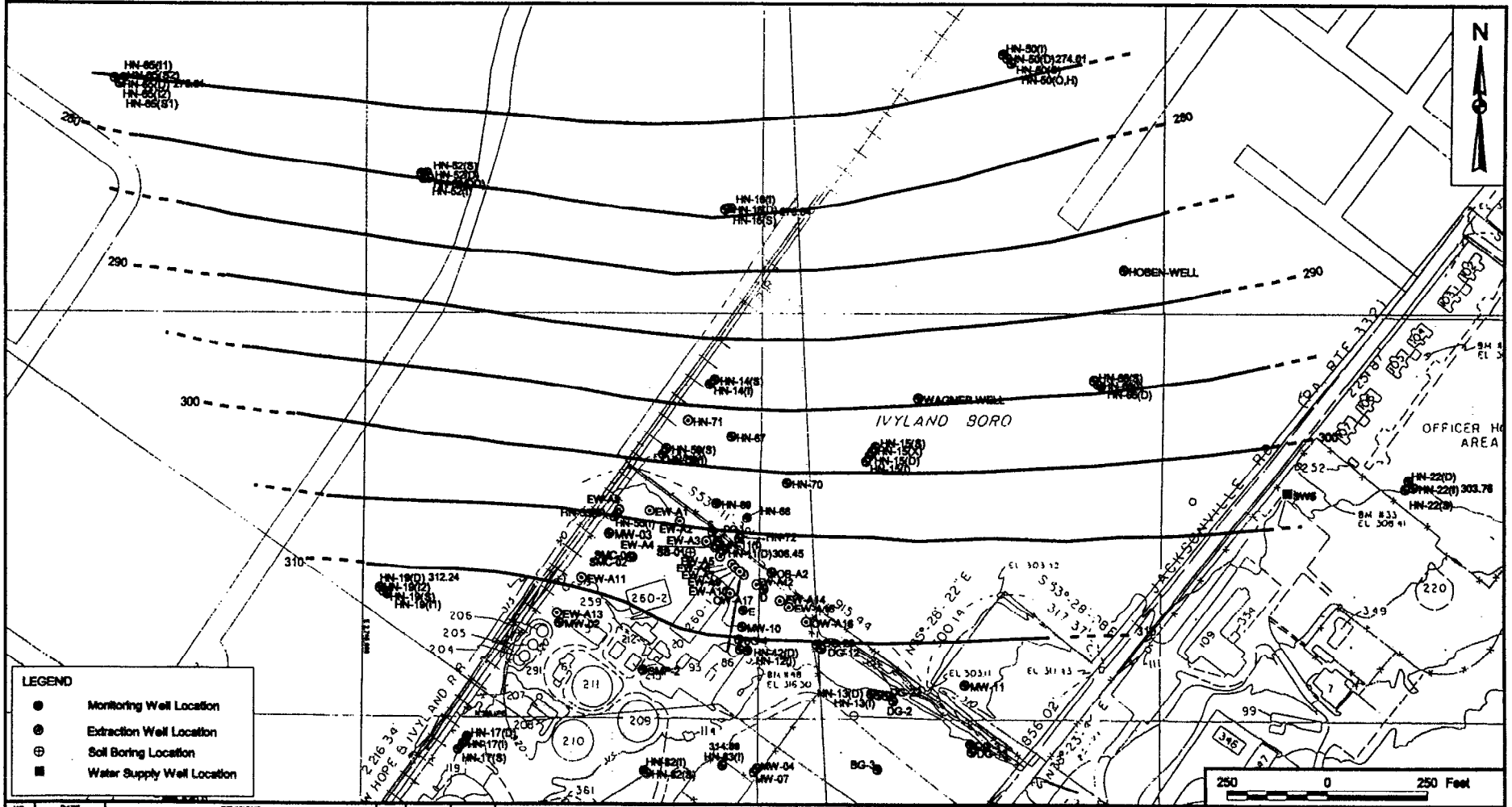
DRAWN BY J. BELLONE	DATE 2/23/00
CHECKED BY	DATE
COST/SCHEDULE-AREA	
SCALE AS NOTED	

Tetra Tech NUS, Inc.

POTENTIOMETRIC SURFACE MAP
DECEMBER 1997
HYDROGEOLOGIC UNIT B
NAWC WARMINSTER, PENNSYLVANIA

CONTRACT NUMBER 7603	OWNER NUMBER
APPROVED BY	DATE
APPROVED BY	DATE
DRAWING NO	REV 0

FIGURE 5



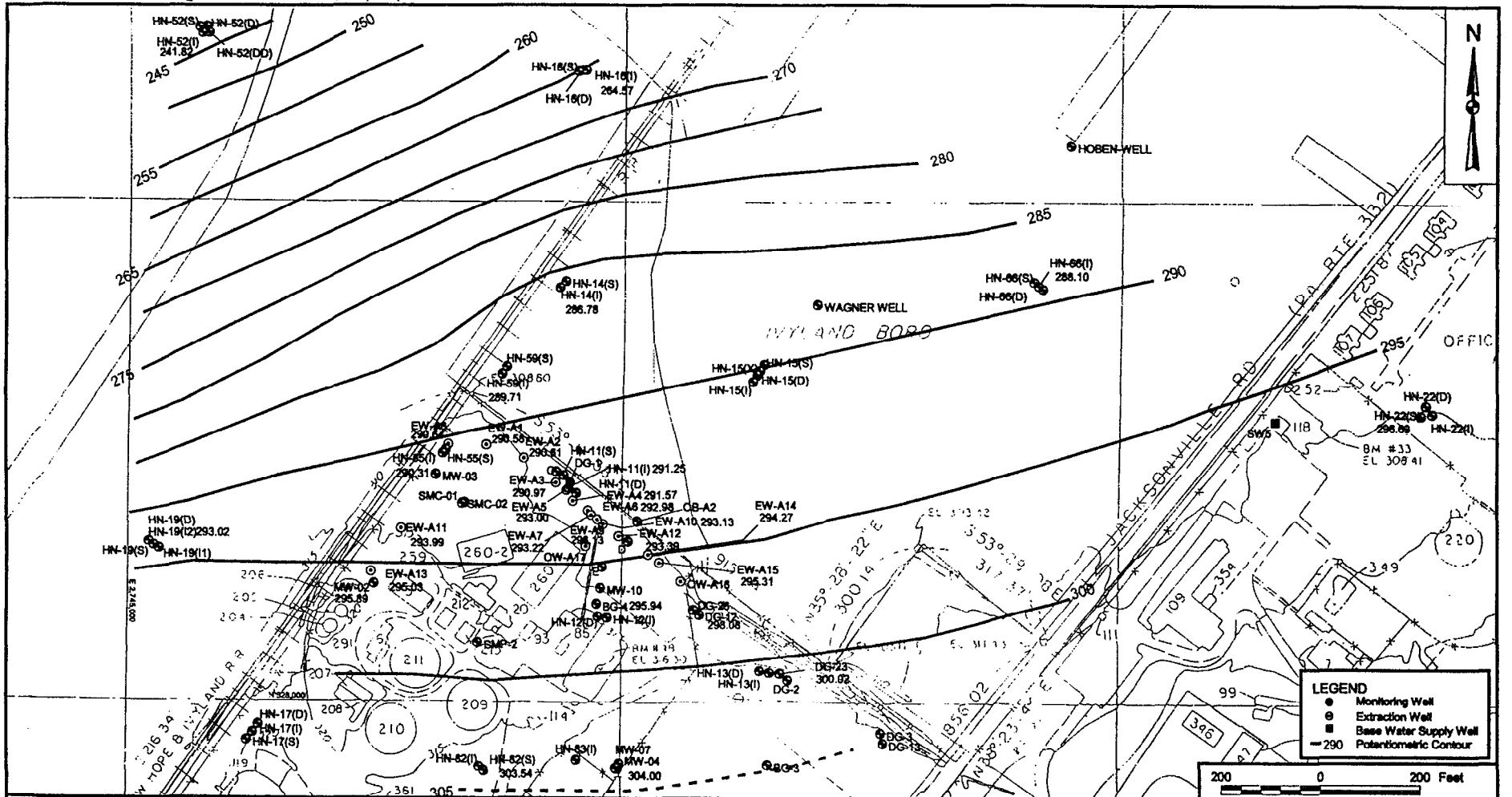
NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY: J. BELLONE	DATE: 3/23/98
CHECKED BY:	DATE:
COST/SCHEDULE-AREA:	
SCALE: AS NOTED	

Tetra Tech NUS, Inc.

POTENTIOMETRIC SURFACE MAP
DECEMBER 1997
HYDROGEOLOGIC UNIT C
NAWC WARMINSTER, PENNSYLVANIA

CONTRACT NUMBER: 7603	OWNER NUMBER:
APPROVED BY:	DATE:
APPROVED BY:	DATE:
DRAWING NO: FIGURE 6	REV: 0



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

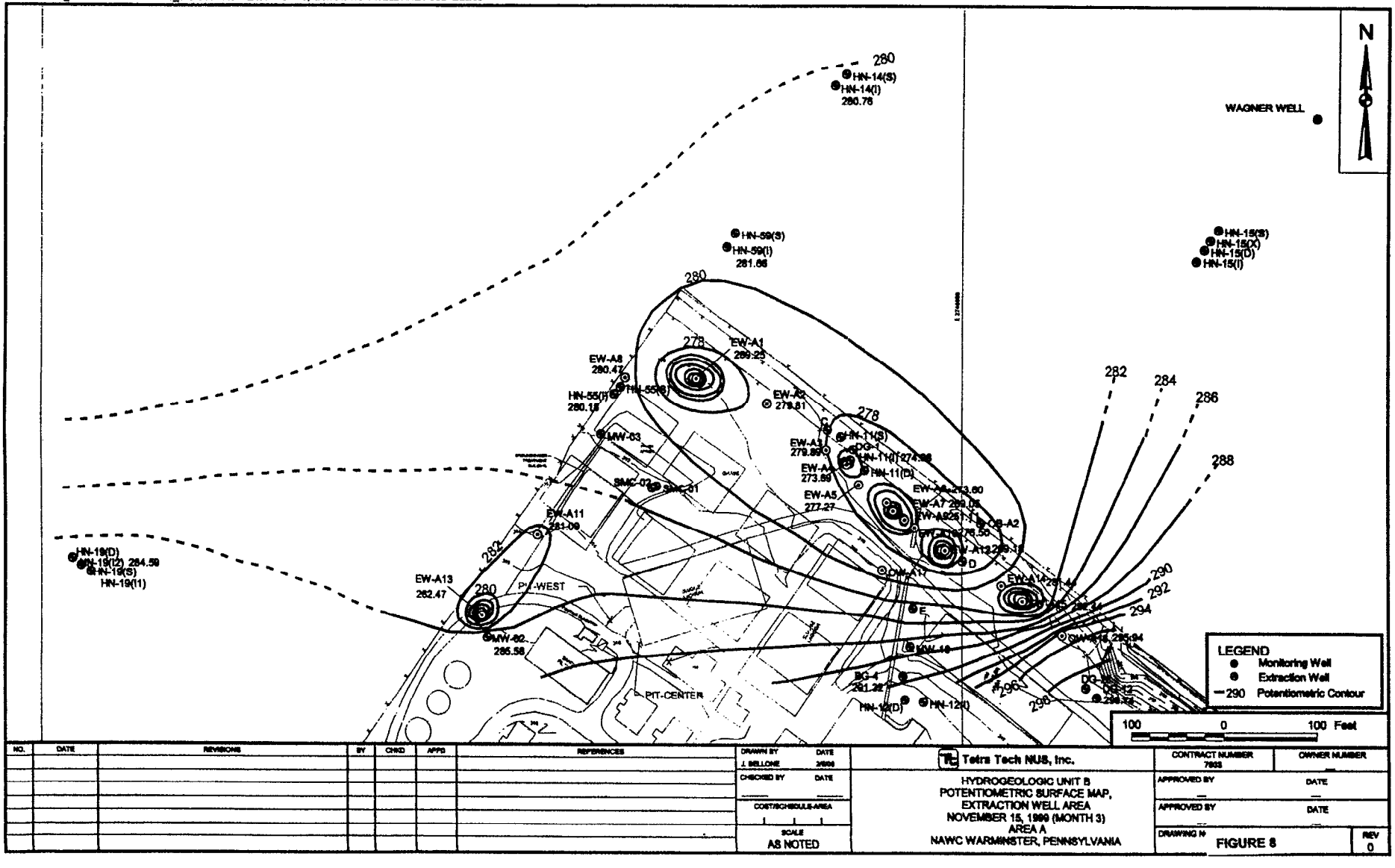
DRAWN BY / DATE	J. BELLONE 2/4/00
CHECKED BY / DATE	
COST/SCHEDULE-AREA	
SCALE	AS NOTED

Tetra Tech NUS, Inc.

HYDROGEOLOGIC UNIT B
POTENTIOMETRIC SURFACE MAP
PRIOR TO EXTRACTION SYSTEM STARTUP
JUNE 21, 1999 ("DAY - 7")
AREA A
NAWC WARMINSTER, PENNSYLVANIA

CONTRACT NUMBER 7803	OWNER NUMBER
APPROVED BY / DATE	
APPROVED BY / DATE	
DRAWING NO.	REV 0

FIGURE 7



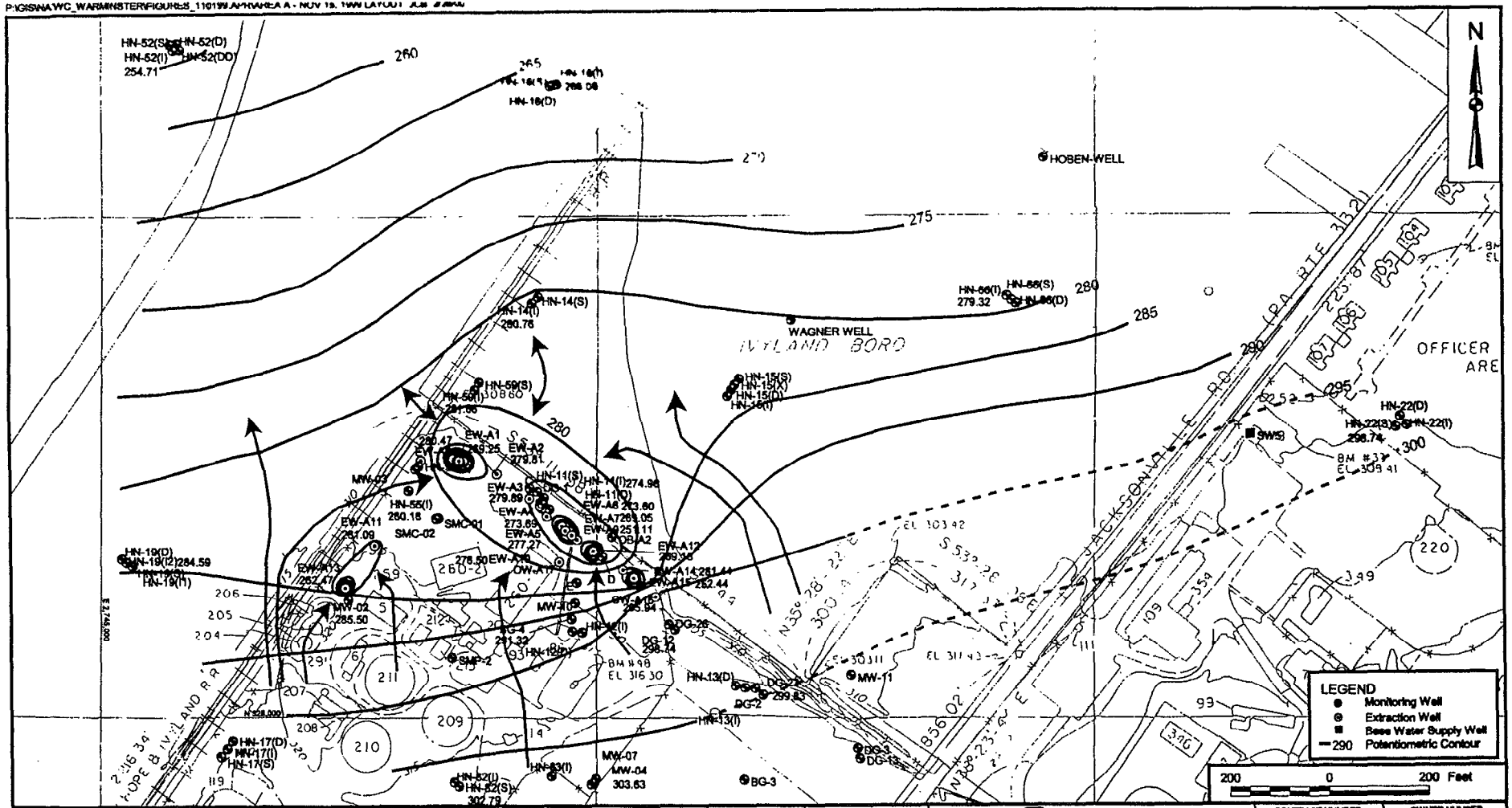
NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY J. BELLONE DATE 3/8/00
CHECKED BY DATE
COST/SCHEDULE-AREA
SCALE AS NOTED

Tetra Tech NUS, Inc.

HYDROGEOLOGIC UNIT B
POTENTIOMETRIC SURFACE MAP,
EXTRACTION WELL AREA
NOVEMBER 15, 1999 (MONTH 3)
AREA A
NAWC WARMINSTER, PENNSYLVANIA

CONTRACT NUMBER 7803 | OWNER NUMBER
APPROVED BY DATE
APPROVED BY DATE
DRAWING N FIGURE 8 REV 0



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY J. BELLONE	DATE 3/500
CHECKED BY	DATE
COST/SCHEDULE-AREA	
SCALE AS NOTED	

Tetra Tech NUS, Inc.

HYDROGEOLOGIC UNIT B
POTENTIOMETRIC SURFACE MAP
NOVEMBER 15, 1999 (MONTH 3)
AREA A
NAWC WARMINSTER, PENNSYLVANIA

CONTRACT NUMBER 7803	OWNER NUMBER
APPROVED BY	DATE
APPROVED BY	DATE
DRAWING NO. FIGURE 9	REV 0

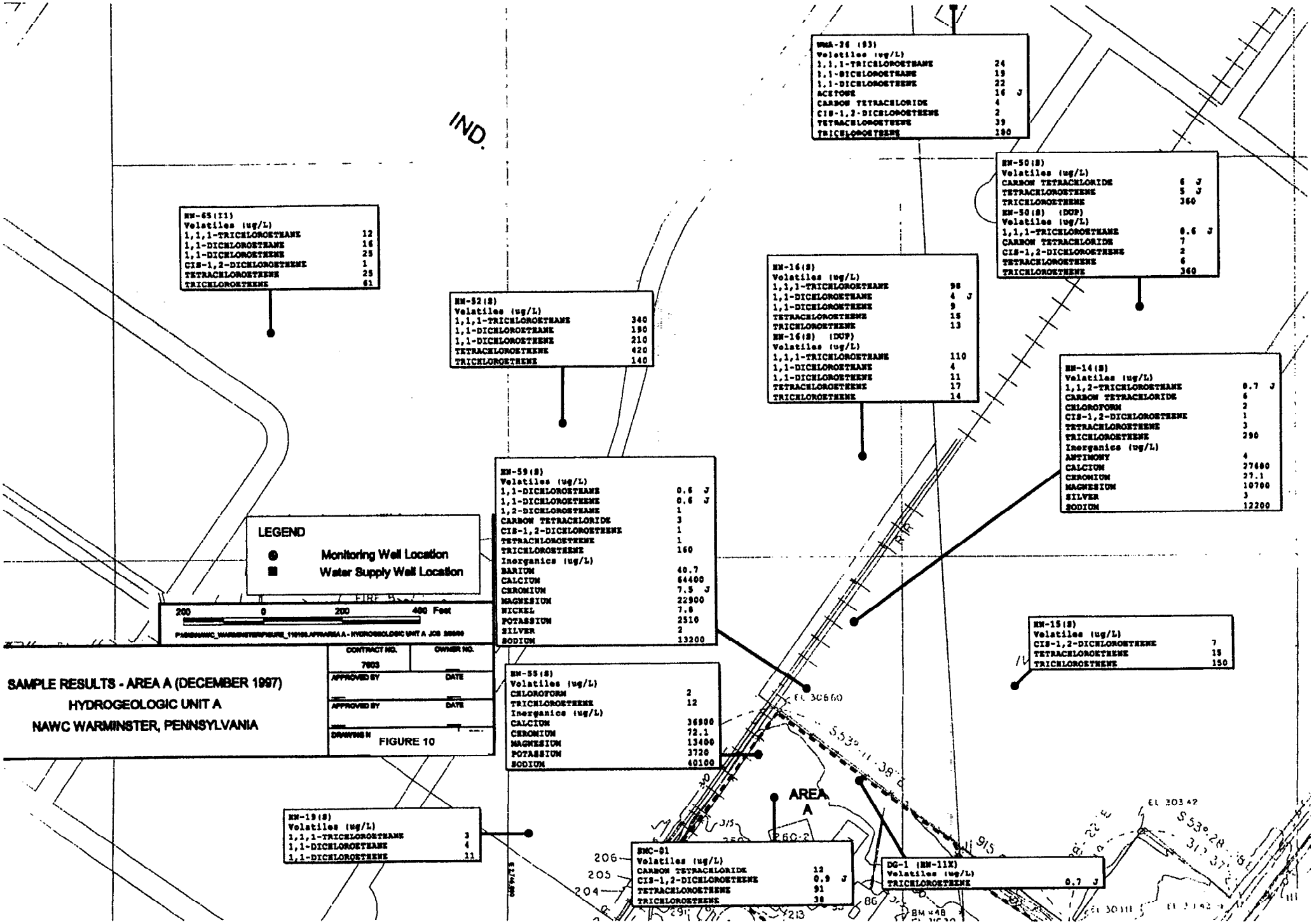
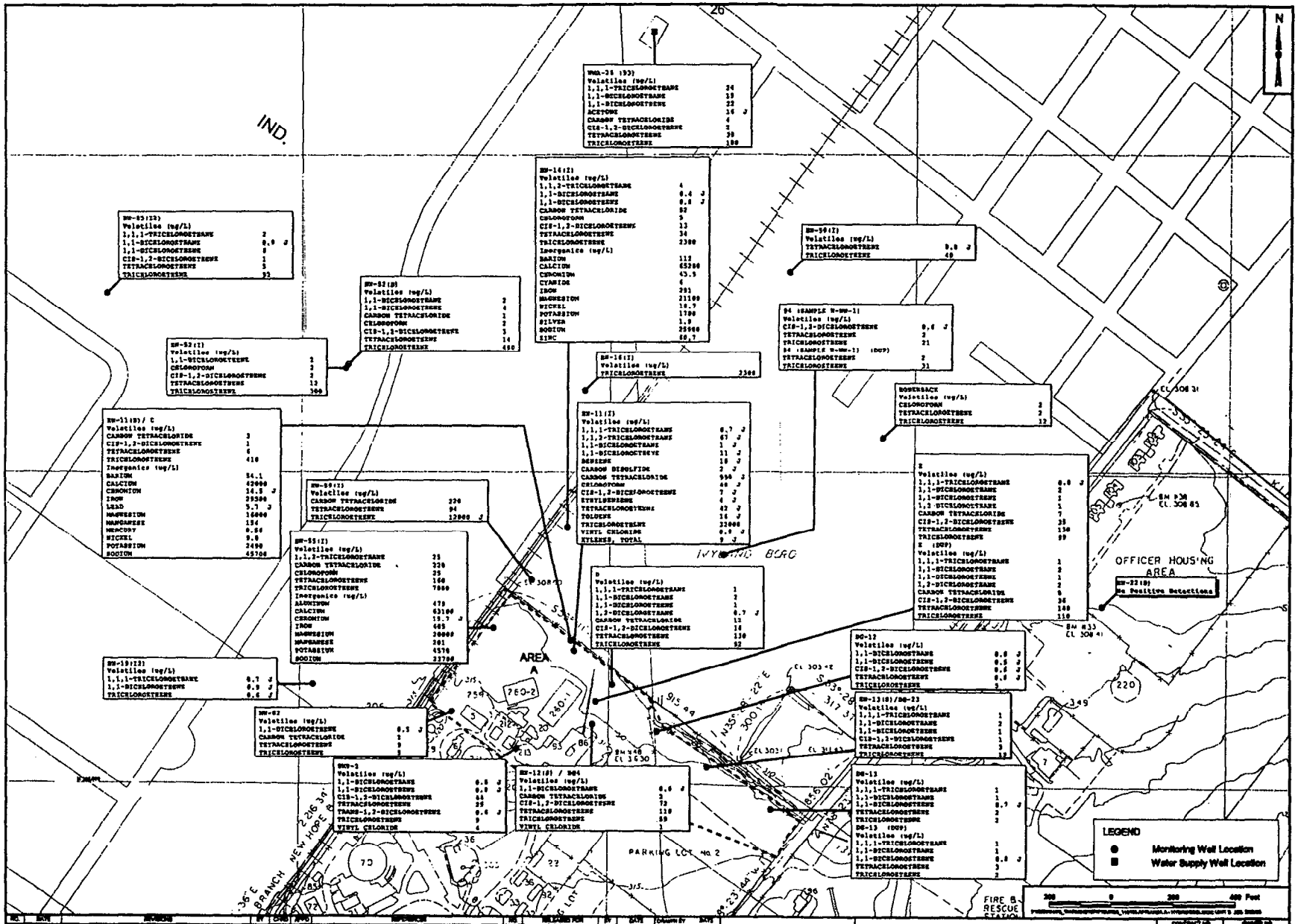
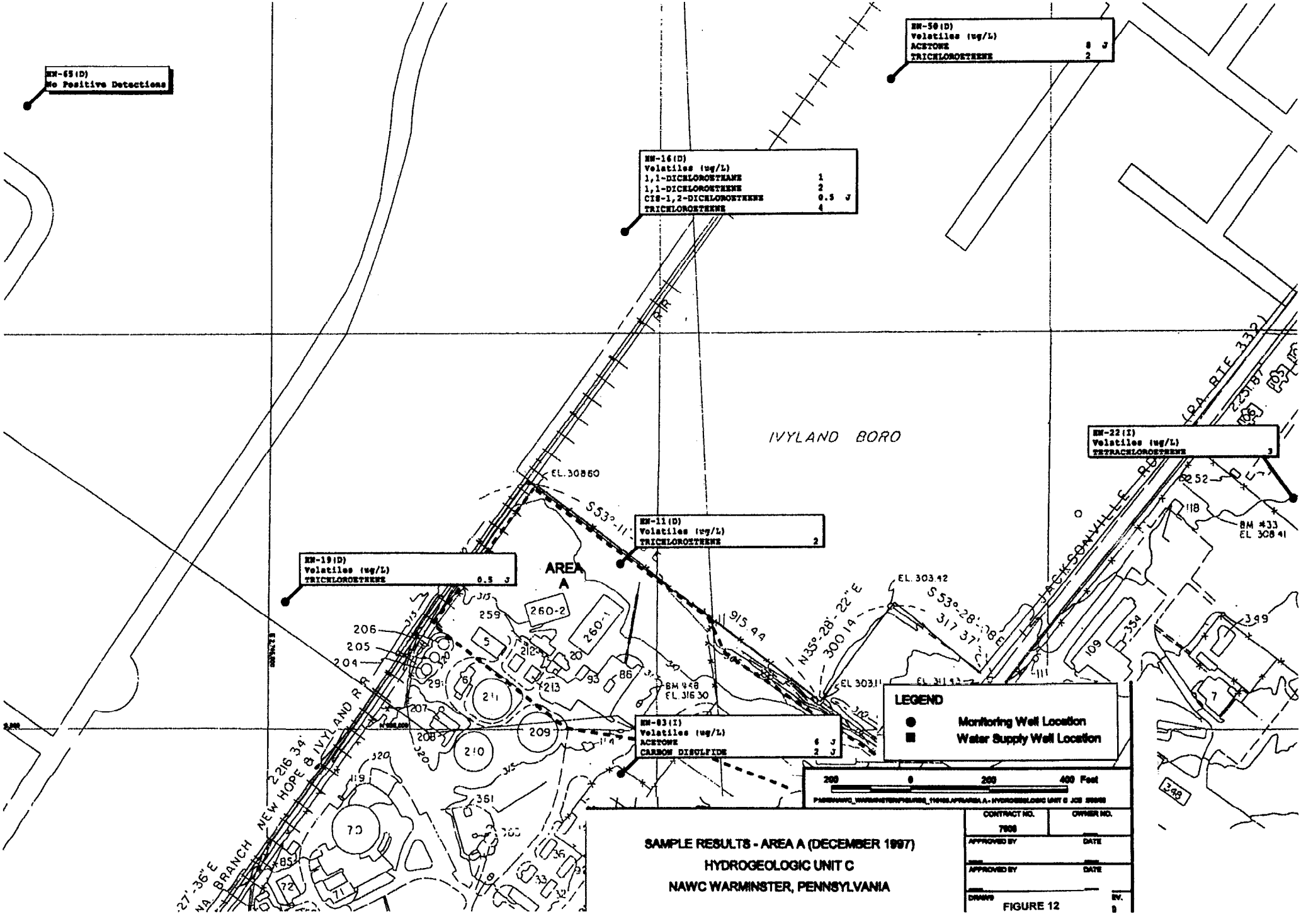
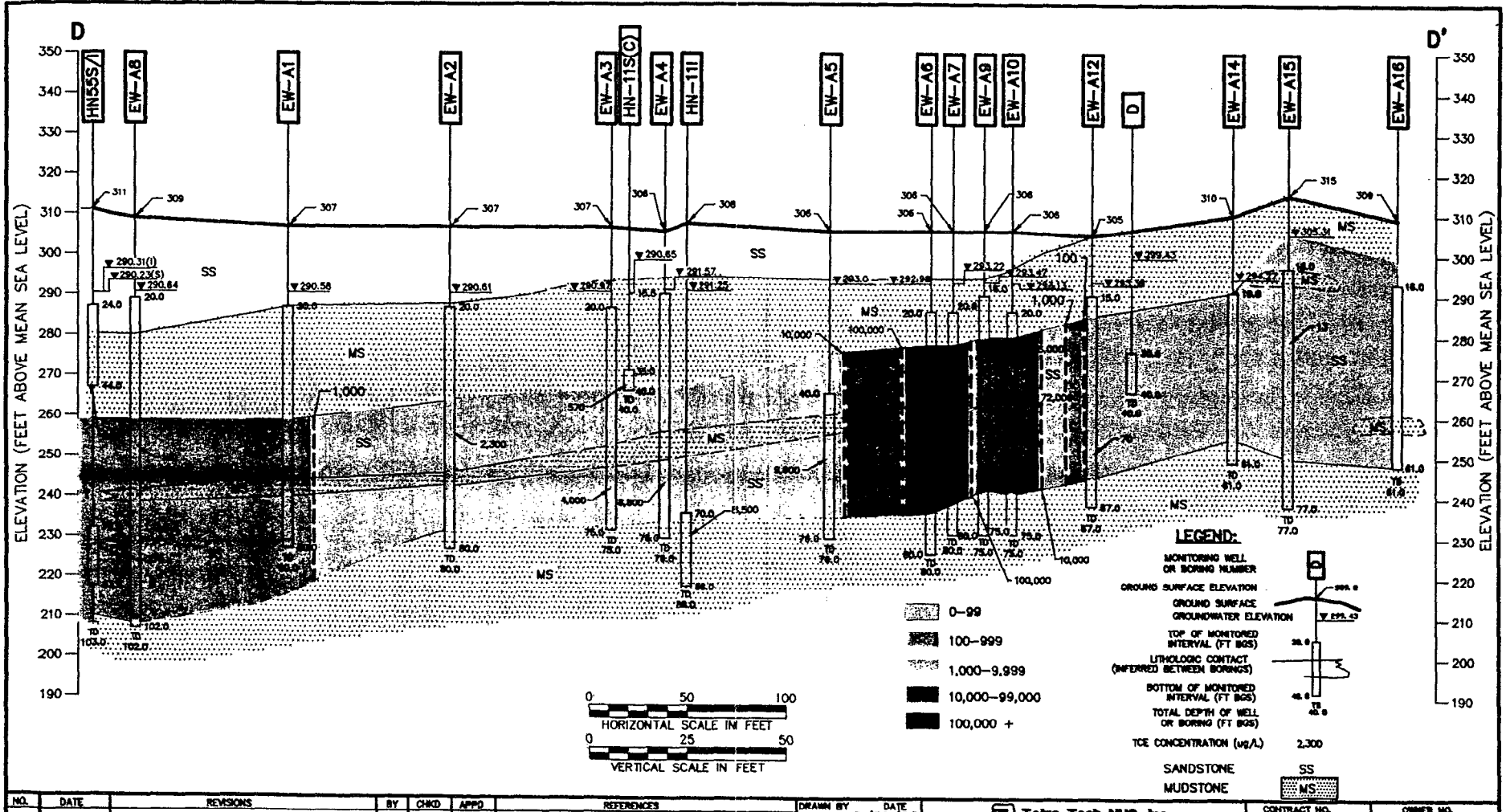

IND.
MW-26 (93)
Volatiles (ug/L)
1,1,1-TRICHLOROETHANE 24
1,1-DICHLOROETHANE 19
1,1-DICHLOROETHENE 22
ACETONE 16 J
CARBON TETRACHLORIDE 4
CIS-1,2-DICHLOROETHENE 2
TETRACHLOROETHENE 39
TRICHLOROETHENE 180
RW-50(S)
Volatiles (ug/L)
CARBON TETRACHLORIDE 6 J
TETRACHLOROETHENE 5 J
TRICHLOROETHENE 360
RW-50(S) (DUP)
Volatiles (ug/L)
1,1,1-TRICHLOROETHANE 0.6 J
CARBON TETRACHLORIDE 7
CIS-1,2-DICHLOROETHENE 2
TETRACHLOROETHENE 6
TRICHLOROETHENE 360
RW-65(I1)
Volatiles (ug/L)
1,1,1-TRICHLOROETHANE 12
1,1-DICHLOROETHANE 16
1,1-DICHLOROETHENE 25
CIS-1,2-DICHLOROETHENE 1
TETRACHLOROETHENE 25
TRICHLOROETHENE 61
RW-52(S)
Volatiles (ug/L)
1,1,1-TRICHLOROETHANE 340
1,1-DICHLOROETHANE 190
1,1-DICHLOROETHENE 210
TETRACHLOROETHENE 420
TRICHLOROETHENE 140
RW-16(S)
Volatiles (ug/L)
1,1,1-TRICHLOROETHANE 98
1,1-DICHLOROETHANE 4 J
1,1-DICHLOROETHENE 9
TETRACHLOROETHENE 15
TRICHLOROETHENE 13
RW-16(S) (DUP)
Volatiles (ug/L)
1,1,1-TRICHLOROETHANE 110
1,1-DICHLOROETHANE 4
1,1-DICHLOROETHENE 11
TETRACHLOROETHENE 17
TRICHLOROETHENE 14
RW-14(S)
Volatiles (ug/L)
1,1,2-TRICHLOROETHANE 0.7 J
CARBON TETRACHLORIDE 6
CHLOROFORM 2
CIS-1,2-DICHLOROETHENE 1
TETRACHLOROETHENE 3
TRICHLOROETHENE 290
Inorganics (ug/L)
ANTIMONY 4
CALCIUM 27600
CHROMIUM 27.1
MAGNESIUM 10700
SILVER 3
SODIUM 12200
RW-59(S)
Volatiles (ug/L)
1,1-DICHLOROETHANE 0.6 J
1,1-DICHLOROETHENE 0.6 J
1,2-DICHLOROETHANE 1
CARBON TETRACHLORIDE 3
CIS-1,2-DICHLOROETHENE 1
TETRACHLOROETHENE 1
TRICHLOROETHENE 160
Inorganics (ug/L)
BARIUM 40.7
CALCIUM 64400
CHROMIUM 7.5 J
MAGNESIUM 22900
NICKEL 7.8
POTASSIUM 2510
SILVER 2
SODIUM 13200
RW-15(S)
Volatiles (ug/L)
CIS-1,2-DICHLOROETHENE 7
TETRACHLOROETHENE 15
TRICHLOROETHENE 150
RW-55(S)
Volatiles (ug/L)
CHLOROFORM 2
TRICHLOROETHENE 12
Inorganics (ug/L)
CALCIUM 36900
CHROMIUM 72.1
MAGNESIUM 13400
POTASSIUM 3720
SODIUM 40100
RW-19(S)
Volatiles (ug/L)
1,1,1-TRICHLOROETHANE 3
1,1-DICHLOROETHANE 4
1,1-DICHLOROETHENE 11
SMC-01
Volatiles (ug/L)
CARBON TETRACHLORIDE 12
CIS-1,2-DICHLOROETHENE 0.9 J
TETRACHLOROETHENE 91
TRICHLOROETHENE 38
DG-1 (RW-11X)
Volatiles (ug/L)
TRICHLOROETHENE 0.7 J
LEGEND
Monitoring Well Location
Water Supply Well Location
200 0 200 400 Feet
AREA A
SAMPLE RESULTS - AREA A (DECEMBER 1997)
HYDROGEOLOGIC UNIT A
NAWC WARMINSTER, PENNSYLVANIA
CONTRACT NO. 7903
OWNER NO.
APPROVED BY DATE
APPROVED BY DATE
DRAWING N
FIGURE 10

FIGURE 10


MW-35 (53)
Volatiles (ug/L)
1,1,1-TRICHLOROETHANE 24
1,1-DICHLOROETHANE 19
1,1-DICHLOROETHENE 22
ACETONE 16 J
CARBON TETRACHLORIDE 4
cis-1,2-DICHLOROETHENE 4
TETRACHLOROETHENE 38
TRICHLOROETHENE 180
MW-14(2)
Volatiles (ug/L)
1,1,2-TRICHLOROETHANE 4
1,1-DICHLOROETHANE 0.4 J
1,1-DICHLOROETHENE 0.8 J
CARBON TETRACHLORIDE 82
CHLOROFORM 5
CIS-1,2-DICHLOROETHENE 12
TETRACHLOROETHENE 34
TRICHLOROETHENE 2380
Inorganics (ug/L)
BARIUM 112
CALCIUM 65200
CHROMIUM 43.5
CYANIDE 6
IRON 291
MAGNESIUM 21100
NICKEL 14.7
POTASSIUM 1700
SILVER 1.9
SODIUM 25900
ZINC 68.7
MW-50(2)
Volatiles (ug/L)
TETRACHLOROETHENE 0.8 J
TRICHLOROETHENE 48
MW-83(23)
Volatiles (ug/L)
1,1,1-TRICHLOROETHANE 2
1,1-DICHLOROETHANE 0.8 J
1,1-DICHLOROETHENE 8
CIS-1,2-DICHLOROETHENE 1
TETRACHLOROETHENE 9
TRICHLOROETHENE 93
MW-82(2)
Volatiles (ug/L)
1,1-DICHLOROETHANE 2
1,1-DICHLOROETHENE 4
CARBON TETRACHLORIDE 1
CHLOROFORM 2
CIS-1,2-DICHLOROETHENE 5
TETRACHLOROETHENE 14
TRICHLOROETHENE 480
MW-52(2)
Volatiles (ug/L)
1,1-DICHLOROETHENE 2
CHLOROFORM 3
CIS-1,2-DICHLOROETHENE 2
TETRACHLOROETHENE 13
TRICHLOROETHENE 300
94 (SAMPLE W-MW-1)
Volatiles (ug/L)
CIS-1,2-DICHLOROETHENE 0.6 J
TETRACHLOROETHENE 2
TRICHLOROETHENE 21
94 (SAMPLE W-MW-1) (DUP)
TETRACHLOROETHENE 2
TRICHLOROETHENE 21
MW-16(2)
Volatiles (ug/L)
TRICHLOROETHENE 2300
ROSENSACK
Volatiles (ug/L)
CHLOROFORM 2
TETRACHLOROETHENE 2
TRICHLOROETHENE 12
MW-11(2)
Volatiles (ug/L)
1,1,1-TRICHLOROETHANE 0.7 J
1,1,2-TRICHLOROETHANE 67 J
1,1-DICHLOROETHANE 1 J
1,1-DICHLOROETHENE 11 J
BENZENE 18 J
CARBON DISULFIDE 2 J
CARBON TETRACHLORIDE 990 J
CHLOROFORM 48 J
CIS-1,2-DICHLOROETHENE 7 J
ETHYLBENZENE 4 J
TETRACHLOROETHENE 42 J
TOLUENE 16 J
TRICHLOROETHENE 32000
VINYL CHLORIDE 0.8 J
XYLENES, TOTAL 9 J
MW-11(B) / C
Volatiles (ug/L)
CARBON TETRACHLORIDE 3
CIS-1,2-DICHLOROETHENE 1
TETRACHLOROETHENE 4
TRICHLOROETHENE 410
Inorganics (ug/L)
BARIUM 54.1
CALCIUM 42900
CHROMIUM 14.5 J
IRON 29500
LEAD 5.7 J
MAGNESIUM 16000
MANGANESE 156
MERCURY 0.56
NICKEL 9.8
POTASSIUM 2490
SODIUM 45700
MW-50(2)
Volatiles (ug/L)
CARBON TETRACHLORIDE 320
TETRACHLOROETHENE 94
TRICHLOROETHENE 12000 J
MW-55(2)
Volatiles (ug/L)
1,1,2-TRICHLOROETHANE 25
CARBON TETRACHLORIDE 320
CHLOROFORM 25
TETRACHLOROETHENE 160
TRICHLOROETHENE 7800
Inorganics (ug/L)
ALUMINUM 478
CALCIUM 63100
CHROMIUM 13.7 J
IRON 665
MAGNESIUM 20000
MANGANESE 201
POTASSIUM 4570
SODIUM 23700
D
Volatiles (ug/L)
1,1,1-TRICHLOROETHANE 1
1,1,2-TRICHLOROETHANE 2
1,1-DICHLOROETHENE 1
1,2-DICHLOROETHANE 0.7 J
CARBON TETRACHLORIDE 15
CIS-1,2-DICHLOROETHENE 16
TETRACHLOROETHENE 130
TRICHLOROETHENE 52
2
Volatiles (ug/L)
1,1,1-TRICHLOROETHANE 0.8 J
1,1-DICHLOROETHANE 2
1,1-DICHLOROETHENE 1
1,2-DICHLOROETHANE 1
CARBON TETRACHLORIDE 7
CIS-1,2-DICHLOROETHENE 35
TETRACHLOROETHENE 130
TRICHLOROETHENE 99
E (DUP)
Volatiles (ug/L)
1,1,1-TRICHLOROETHANE 1
1,1-DICHLOROETHANE 2
1,1-DICHLOROETHENE 1
1,2-DICHLOROETHANE 2
CARBON TETRACHLORIDE 9
CIS-1,2-DICHLOROETHENE 36
TETRACHLOROETHENE 140
TRICHLOROETHENE 110
MW-23(B)
No Positive Detections
MW-19(23)
Volatiles (ug/L)
1,1,1-TRICHLOROETHANE 0.7 J
1,1-DICHLOROETHENE 0.5 J
TRICHLOROETHENE 0.6 J
MW-82
Volatiles (ug/L)
1,1-DICHLOROETHENE 0.5 J
CARBON TETRACHLORIDE 1
TETRACHLOROETHENE 9
TRICHLOROETHENE 3
MW-1
Volatiles (ug/L)
1,1-DICHLOROETHANE 0.8 J
1,1-DICHLOROETHENE 0.8 J
CIS-1,2-DICHLOROETHENE 64
TETRACHLOROETHENE 25
TRANS-1,2-DICHLOROETHENE 0.6 J
TRICHLOROETHENE 9
VINYL CHLORIDE 4
MW-12(B) / 304
Volatiles (ug/L)
1,1-DICHLOROETHANE 0.6 J
CARBON TETRACHLORIDE 3
CIS-1,2-DICHLOROETHENE 72
TETRACHLOROETHENE 110
TRICHLOROETHENE 59
VINYL CHLORIDE 1
DG-12
Volatiles (ug/L)
1,1-DICHLOROETHANE 0.8 J
1,1-DICHLOROETHENE 0.6 J
CIS-1,2-DICHLOROETHENE 0.8 J
TETRACHLOROETHENE 0.8 J
TRICHLOROETHENE 5
DG-13(B) / DG-23
Volatiles (ug/L)
1,1,1-TRICHLOROETHANE 1
1,1-DICHLOROETHANE 1
1,1-DICHLOROETHENE 1
CIS-1,2-DICHLOROETHENE 1
TETRACHLOROETHENE 1
TRICHLOROETHENE 12
DG-11
Volatiles (ug/L)
1,1,1-TRICHLOROETHANE 1
1,1-DICHLOROETHANE 1
1,1-DICHLOROETHENE 0.9 J
TETRACHLOROETHENE 2
TRICHLOROETHENE 2
DG-11 (DUP)
Volatiles (ug/L)
1,1,1-TRICHLOROETHANE 1
1,1-DICHLOROETHANE 1
1,1-DICHLOROETHENE 0.8 J
TETRACHLOROETHENE 3
TRICHLOROETHENE 2
IND.
AREA A
OFFICER HOUSING AREA
PARKING LOT NO 2
FIRE & RESCUE STATION
INVADING BORG
LEGEND
Monitoring Well Location
Water Supply Well Location
N
Tetra Tech NUS, Inc.
SAMPLE RESULTS - AREA A (DECEMBER 1997)
HYDROGEOLOGIC UNIT B
NAWC WARMINSTER, PENNSYLVANIA
FIGURE 11


MW-65(D)
No Positive Detections
MW-16(D)
Volatiles (ug/L)
1,1-DICHLOROETHANE 1
1,1-DICHLOROETHENE 2
CIS-1,2-DICHLOROETHENE 0.5 J
TRICHLOROETHENE 4
MW-50(D)
Volatiles (ug/L)
ACETONE 8 J
TRICHLOROETHENE 2
MW-22(I)
Volatiles (ug/L)
TETRACHLOROETHENE 3
MW-11(D)
Volatiles (ug/L)
TRICHLOROETHENE 2
MW-19(D)
Volatiles (ug/L)
TRICHLOROETHENE 0.5 J
MW-03(I)
Volatiles (ug/L)
ACETONE 6 J
CARBON DISULFIDE 2 J
IVYLAND BORO
AREA A
EL. 308.60
EL. 303.42
EL. 303.11
BM #33
EL. 308.41
BM #48
EL. 316.30
915.94
N35°-28'-22"E
300.14
S53°-28'-38"E
317.37
S53°-11'
NEW HOPE & IVYLAND R.R.
JACKSONVILLE RD.
LEGEND
Monitoring Well Location
Water Supply Well Location
200 0 200 400 Feet
SAMPLE RESULTS - AREA A (DECEMBER 1997)
HYDROGEOLOGIC UNIT C
NAWC WARMINSTER, PENNSYLVANIA
CONTRACT NO. 7606
OWNER NO.
APPROVED BY DATE
APPROVED BY DATE
DRAWN
FIGURE 12



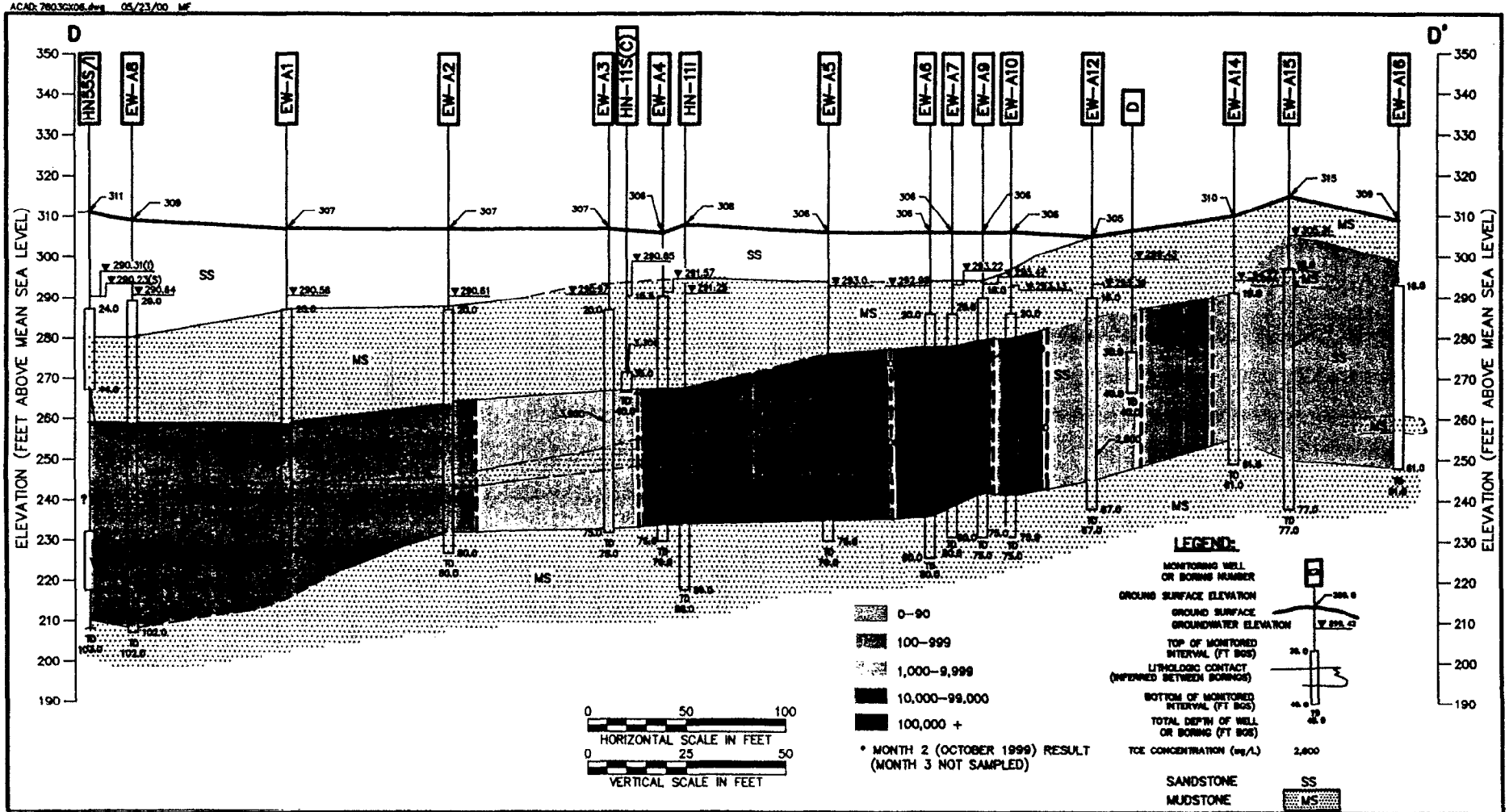
NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY HJP DATE 2/21/00
CHECKED BY DATE
COST/SCHED--AREA
SCALE AS NOTED

Tetra Tech NUS, Inc.

TCE CONCENTRATIONS (ug/L)
"DAY-3" (JUNE 28-30, 1999)
EXTRACTION WELL AREA
FORMER NAWC, WARMINSTER, PA

CONTRACT NO. 7603
OWNER NO. 0290
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 13
REV. 0



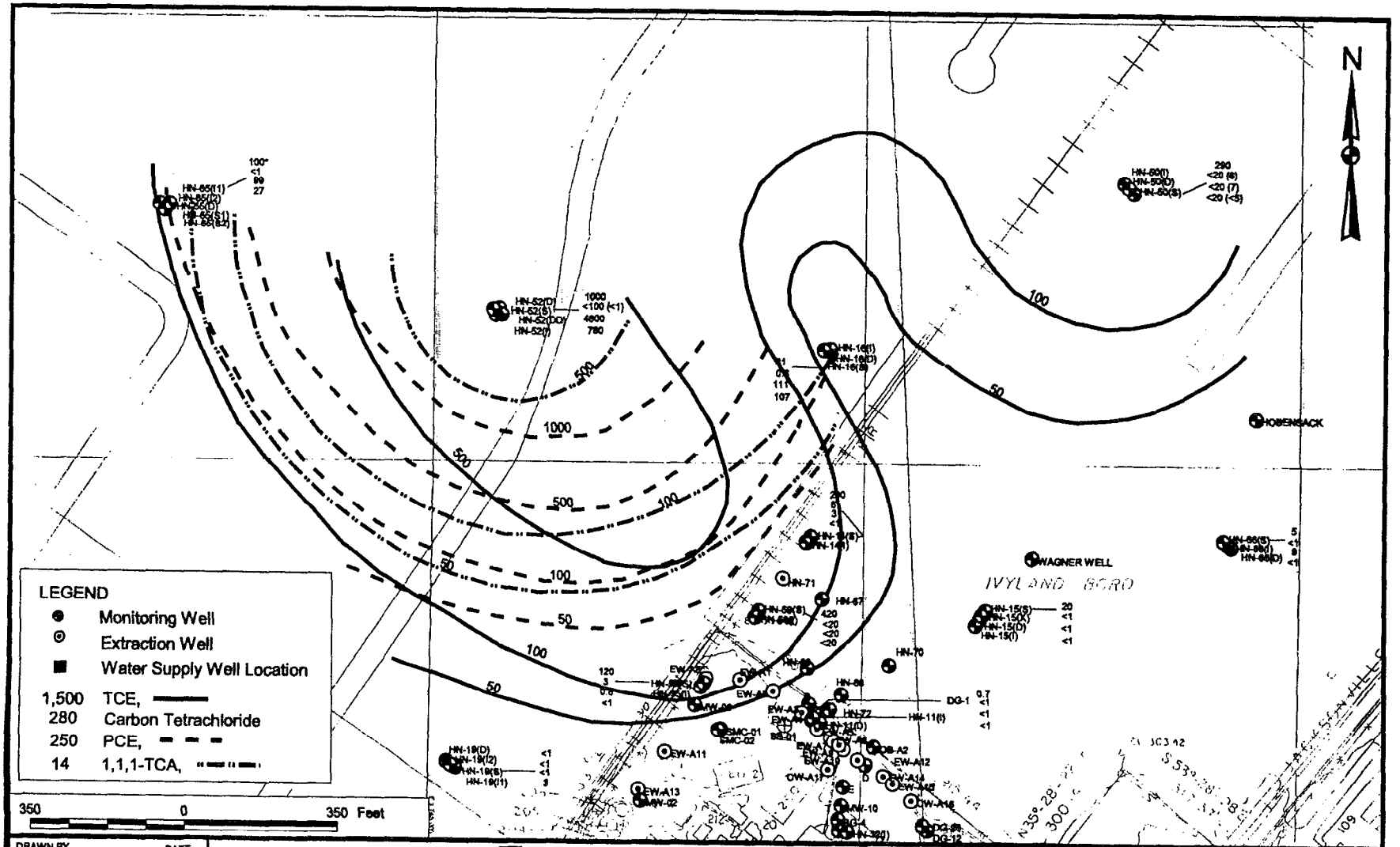
NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY / DATE	HJP 2/18/00
CHECKED BY / DATE	
COST/SCHED-AREA	
SCALE	AS NOTED

Tetra Tech NUS, Inc.

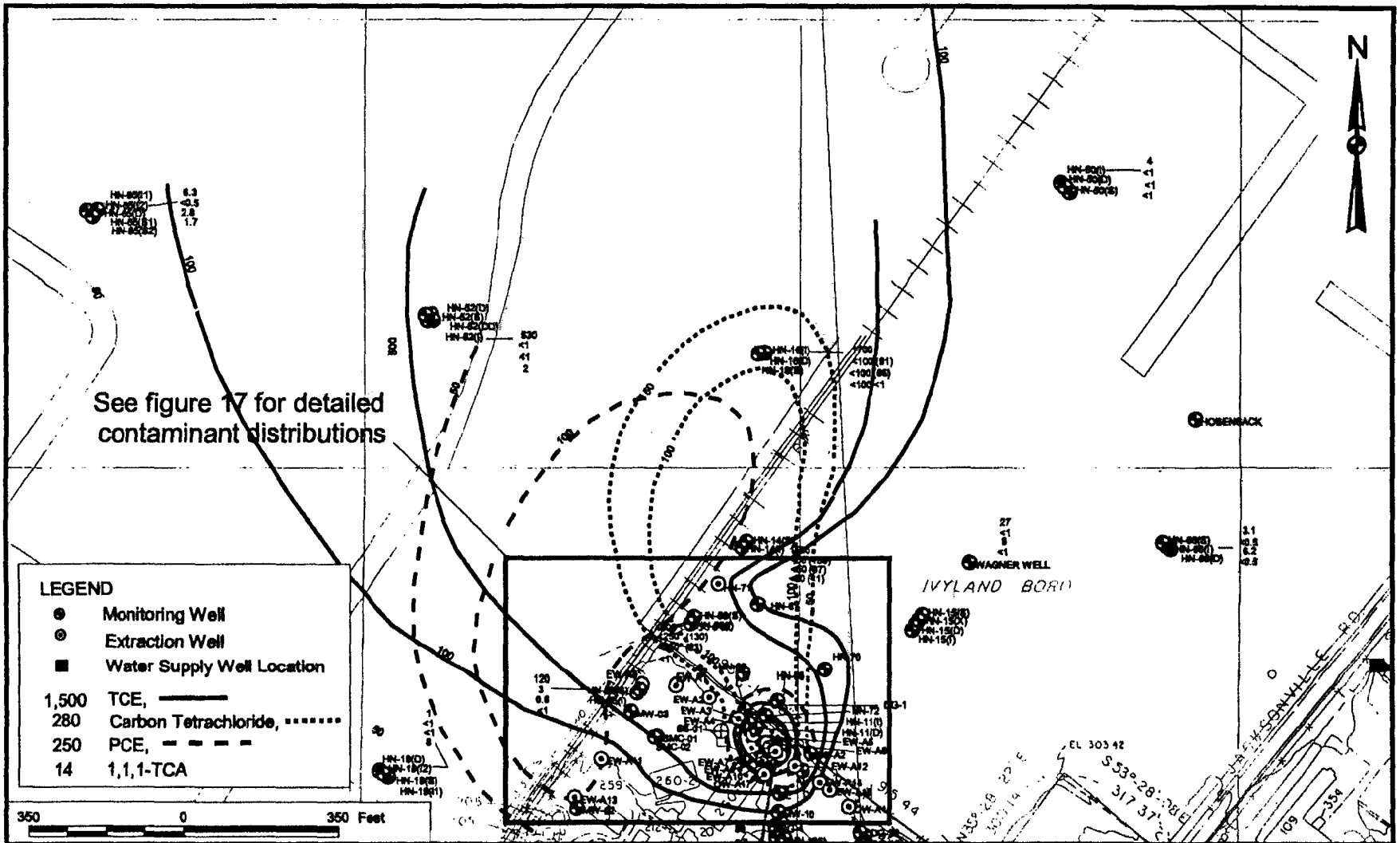
TCE CONCENTRATIONS (ug/L)
"MONTH 3" (NOVEMBER 15-16, 1999)
EXTRACTION WELL AREA
FORMER NAWC, WARMINSTER, PA

CONTRACT NO.	7603
OWNER NO.	0290
APPROVED BY / DATE	
APPROVED BY / DATE	
DRAWING NO.	FIGURE 14



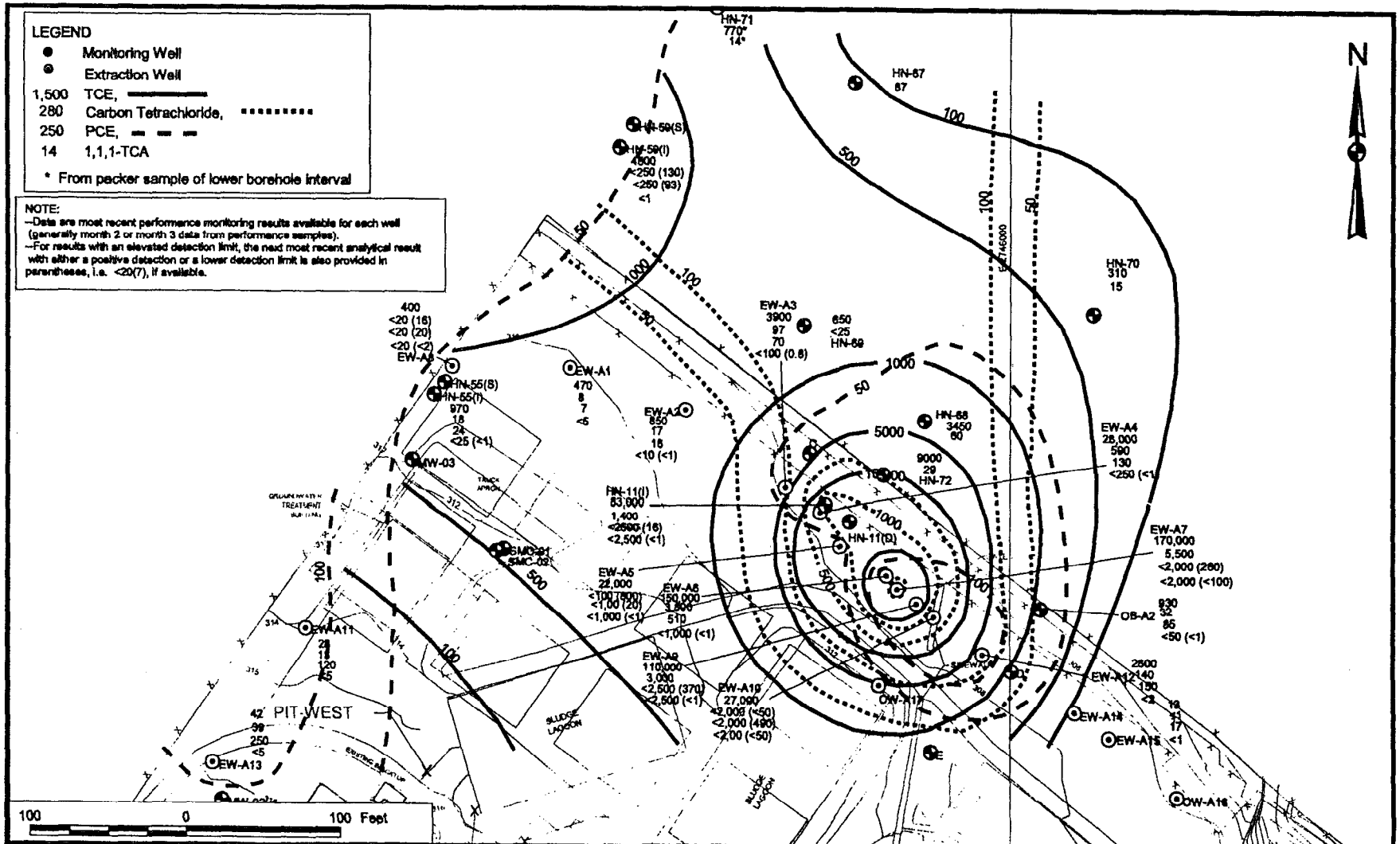
DRAWN BY: J. BELLONE	DATE: 9/1/00	Tetra Tech NUS, Inc.	CONTRACT NUMBER: 7603 / OWNER NUMBER: —
CHECKED BY: —	DATE: —	INTERPRETED ISOCONCENTRATION CONTOURS, OCTOBER-NOVEMBER 1999 SELECTED CHEMICALS, ug/L HYDROGEOLOGIST UNIT A NAWC WARMINSTER, PENNSYLVANIA	APPROVED BY: — / DATE: —
COST/SCHEDULE-AREA			APPROVED BY: — / DATE: —
SCALE: AS NOTED			DRAWING NO.: FIGURE 15 / REV: 0

P:\GIS\NAWC_WARMINSTER\WAVEY_ROD.APR\UNIT A CHEMICAL CONCENTRATIONS JCB 9/1/00



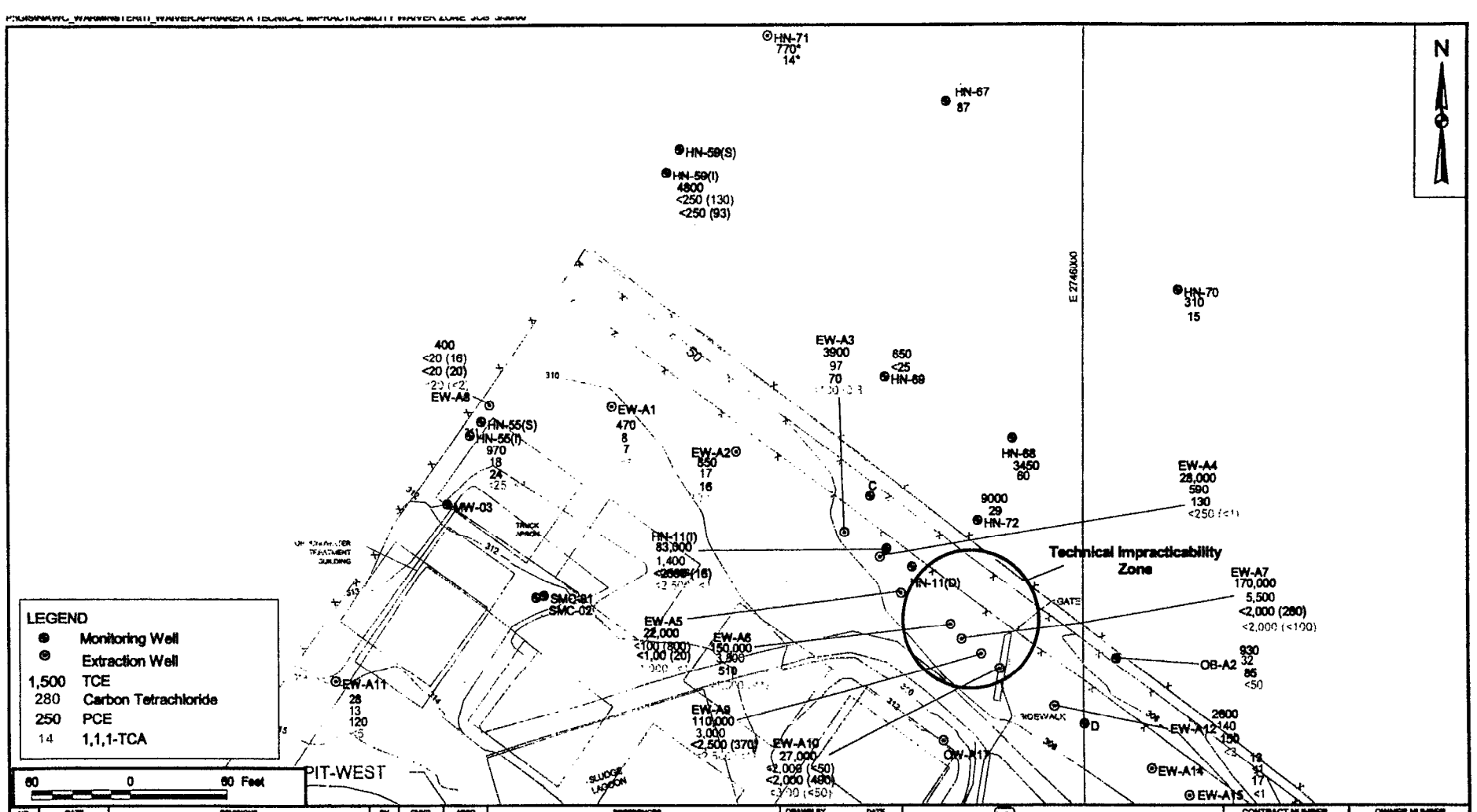
DRAWN BY: J. BELLONE — DATE: 9/1/00	Tetra Tech NUS, Inc.	CONTRACT NUMBER: 7603	OWNER NUMBER: —
CHECKED BY: — — DATE: —	INTERPRETED ISOCONCENTRATION CONTOURS, OCTOBER-NOVEMBER 1999 SELECTED CHEMICALS, ug/L HYDROGEOLOGIC UNIT B NAWC WARMINSTER, PENNSYLVANIA	APPROVED BY: — DATE: —	
COST/SCHEDULE-AREA:		APPROVED BY: — DATE: —	
SCALE: AS NOTED		DRAWING NO.: FIGURE 16	REV: 0

P:\GIS\NAWC_WARMINSTER\NAVY_ROD.APR\UNIT B CHEMICAL CONCENTRATIONS JCB 9/1/00



DRAWN BY: J. BELLONE	DATE: 9/1/00	Tetra Tech NUS, Inc.	CONTRACT NUMBER: 7603 / OWNER NUMBER: —
CHECKED BY: —	DATE: —	INTERPRETED ISOCONCENTRATION CONTOURS OCTOBER-NOVEMBER 1999 SELECTED CHEMICALS, ug/L EXTRACTION WELL AREA HYDROGEOLOGIC UNIT B NAWC WARMINSTER, PENNSYLVANIA	APPROVED BY: — / DATE: —
COST/SCHEDULE-AREA			APPROVED BY: — / DATE: —
SCALE: AS NOTED			DRAWING NO.: FIGURE 17 / REV: 0

P:\GIS\NAWC_WARMINSTER\NAVY_ROD.APR\UNIT B - INSET CHEMICAL CONCENTRATIONS JCB 9/1/00



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

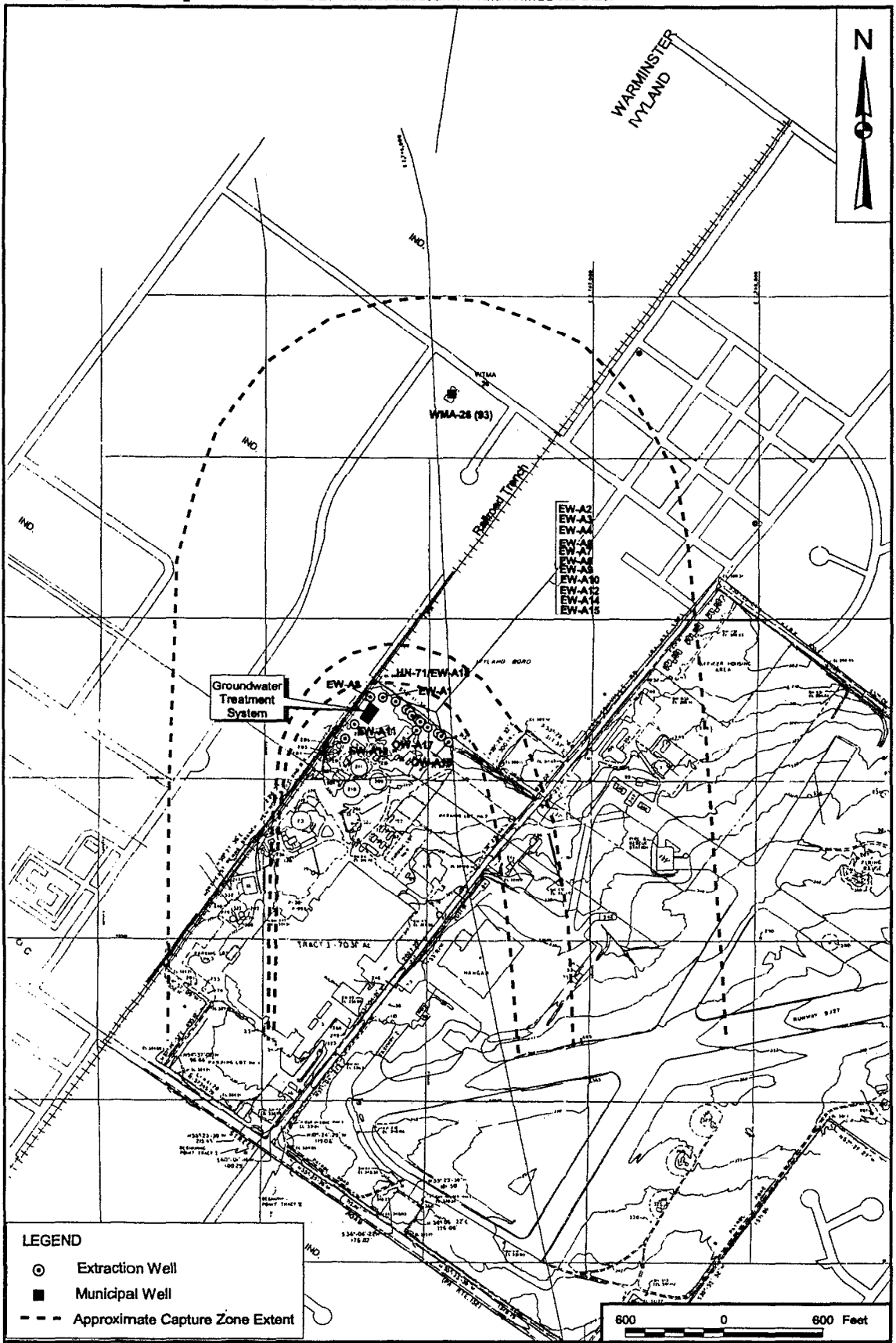
DRAWN BY J. BELLONE DATE 3/27/00
CHECKED BY DATE
COST/SCHEDULE-AREA
SCALE AS NOTED

Tetra Tech NUS, Inc.

TECHNICAL IMPRACTICABILITY WAIVER ZONE
AREA A GROUNDWATER
NAWC WARMINSTER, PENNSYLVANIA

CONTRACT NUMBER 7553 | OWNER NUMBER
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO FIGURE 18 REV 0

P:\GIS\NAWC_WARMINSTER\FIGURES_110199.APR\SITE MAP AND EXTRACTION WELLS LOCATION - ALTERNATIVE 2 JCB 6/12/00



DRAWN BY J. BELLONE	DATE 3/30/00	Tetra Tech NUS, Inc.	CONTRACT NUMBER 7803 / OWNER NUMBER
CHECKED BY	DATE		APPROVED BY / DATE
COST/SCHEDULE-AREA		SITE MAP AND EXTRACTION WELLS LOCATION - ALTERNATIVE 2 AREA A GROUNDWATER FFS NAWC WARMINSTER, PENNSYLVANIA	APPROVED BY / DATE
SCALE AS NOTED			DRAWING NO FIGURE 19 / REV 0

APPENDIX A

COMMONWEALTH OF PENNSYLVANIA
LETTER OF CONCURRANCE

Pennsylvania Department of Environmental Protection
Lee Park, Suite 6010
55 North Lane
Conshohocken, PA 19428

August 23, 2000

Southeast Regional Office

610-832-6012
Fax 610-832-6022

Mr. Orlando Monaco
Naval Facilities Engineering Command (NAVFACENGCOM)
Northern Division
Environmental Contracts Branch, Mailstop No. 82
10 Industrial Highway
Lester, PA 19113

Re: Warminster Naval Air Warfare Center NPL Site
Warminster Township
Bucks County
Record of Decision, Operable Unit 1A
Letter of Concurrence

Dear Mr. Monaco:

The Record of Decision (ROD) dated August 2000, for Operable Unit 1A (OU 1A), which pertains to groundwater at Area A, Warminster Naval Air Warfare Center (the Site), has been reviewed by the Commonwealth of Pennsylvania's Department of Environmental Protection (Department).

This ROD includes the following major components:

1. Area A is an area of the Warminster NAWC that was identified as a disposal area; disposal areas in Area A included Sites 1, 2, 3, and the former wastewater lagoons.

2. A Final ROD for Area A media other than groundwater, OU 9, was signed in June 2000.

3. An Interim ROD for OU 1 was signed in 1993; it included the design and construction of a pump and treat system for Area A groundwater. The system has been built, and is successfully operating. An "Operating Properly and Successfully" determination is being developed by the Navy and will have EPA concurrence.

4. This ROD makes the remedy a Final Remedy with the following provisions:

   a. Continued operation of the existing system with discharge to the unnamed tributary of Little Neshaminy Creek will be monitored by continued submission to the Department of monthly monitoring reports.

   b. A waiver of the ARAR requiring restoration of the aquifer for a tightly defined area where dense non-aqueous phase liquid (DNAPL) is present.

c. Provision for institutional controls for extraction and use of groundwater which might impact the operation of the remedy, and continued extraction and treatment of water from the Warminster Township Municipal Authority well 26.

d. A five-year review will be conducted.

The Department hereby concurs with the remedy selected for the Warminster Naval Air Warfare Center NPL Site OU 1A for the following reasons and with the following conditions:

Pennsylvania's Land Recycling and Environmental Remediation Standards Act, Act 2 of 1995, 35 P.S. Sections 6026.101 - 6029.909 ("Act2"), Pennsylvania's Solid Waste Management Act, Act 97 of 1980, as amended, 35 P.S. Section 6018.101 et seq. ("Act 97"), and the regulations adopted pursuant to these statutes are ARARs for this response. Implementation of any component or components of this response will not necessarily result in protection from liability pursuant to Act 2, for any party.

This concurrence with the selected remedial actions is not intended to provide any assurance pursuant to CERCLA Section 104(c)(3), 42 U.S.C. Section 9604(c)(3).

The Department reserves its rights and msponsibilities to take independent enforcement actions pursuant to state and federal law.

This letter documents the Department's concurrence with the remedy selected by the Navy in the ROD for OU 1A for the Warminster Naval Air Warfare Center NPL Site. If you have any questions regarding this matter, please feel free to contact me at the above telephone number.

Sincerely,

Joseph A. Feola

Joseph A. Feola
Regional Director
Southeast Regional Office

cc: Mr. Fidler
Mr. Beitler
Mr. Danyliw
Mr. Olewiler
Mr. Hartzell
Mr. Sheehan
Ms. Tremont
Ms. Flipse
Mr. Ostrauskas - EPA
Re 30 (GJC00)235-10

APPENDIX B

OU 1 INTERIM ROD - SEPTEMBER 1993

EXCERPTED TABLES AND FIGURES FOR AREA A GROUNDWATER

TABLE 2
OCCURRENCE AND DISTRIBUTION OF MONITORING WELL ORGANICS - SITES 1, 2 and 3
NAWC, WARMINSTER, PENNSYLVANIA
(ug/L)

Compound	CRQL	Frequency of Positive Detection	Range of Positive Detection	Rep Conc
Vinyl chloride	1/10	1/24	1.5	1.5
1,1-Dichloroethene	1/5	13/24	0.175-3	3.0
1,1-Dichloroethane	1/5	14/24	1-8	8.0
1,2-Dichloroethene	5	6/11	1-62	27.0
Cis-1,2-Dichloroethene	1/5	5/13	2-510	138
1,2-Dichloroethane	1/5	4/24	3-3.5	3.5
Trichloroethene	1/5	19/24	0.75-2100	469
Tetrachloroethene	1/5	11/24	3-440	128
1,1,1-Trichloroethane	1/5	9/24	2-10	10.0
Chloroform	1/5	5/24	6-25	13.8
Carbon tetrachloride	1/5	6/24	10-44	16.8
Benzene	1/5	3/24	0.95-2	2.0
Trichlorofluoromethane	5	3/11	10-91	29.8
Toluene	1/5	2/24	3-4	4.0
Ethylbenzene	1/5	1/24	0.2	0.2
Xylenes	1/5	1/24	2	2.0
1,2-Dichlorobenzene	1/10	3/24	0.4-0.7	0.7
1,2-Dichloropropane	1/5	1/24	1	1.0
2-Butanone	5/10	1/13	24	24.0
Di-n-octylphthlate	10	5/12	0.3-3	3.0
Diethylphthalate	10	3/12	0.2-0.375	0.375
Phenanthrene	10	1/12	0.3	0.3
Fluoranthene	10	1/12	0.6	0.6
Pyrene	10	1/12	0.6	0.6
TICs	-	3	+	-

TICs = Tentatively identified compounds
CRQL = Contract Required Quantitation Limit

Adopted from - Halliburton NUS Corporation Phase II Remedial Investigation Report April 1993

TABLE 3
OCCURRENCE AND DISTRIBUTION OF UNFILTERED MONITORING WELL INORGANICS
SITES 1, 2, and 3
NAWC, WARMINSTER, PENNSYLVANIA
(ug/L)

Element	CRDL	Frequency of Positive Detection	Range of Positive Detection	Representative Concentration
Aluminum	200	15/24	854-158000	25820
Arsenic	10	7/24	2-67.5	10.6
Barium	200	13/24	47-4620	873
Cadmium	5	4/24	6-33	9.6
Calcium	5000	13/24	30900-158400	63520
Chromium	10	13/24	2.5-220	49.4
Cobalt	50	10/24	2-118	22.8
Copper	25	7/24	30.5-1660	236
Iron	100	21/24	4330-126280	42010
Lead	3	16/24	1.2-325	85.5
Magnesium	5000	13/24	9080-68500	24120
Manganese	15	22/24	53-32100	5410
Mercury	0.2	3/21	0.3-0.67	0.22
Nickel	40	9/24	10-121	43.6
Potassium	5000	12/24	1030-9110	2850
Silver	10	2/24	4-20	5.58
Sodium	5000	13/24	10900-42500	21230
Thallium	10	1/24	2	1.14
Vanadium	50	6/24	14-101	24.5
Zinc	20	10/24	22-1660	400

CRDL = Contract Required Detection Limit

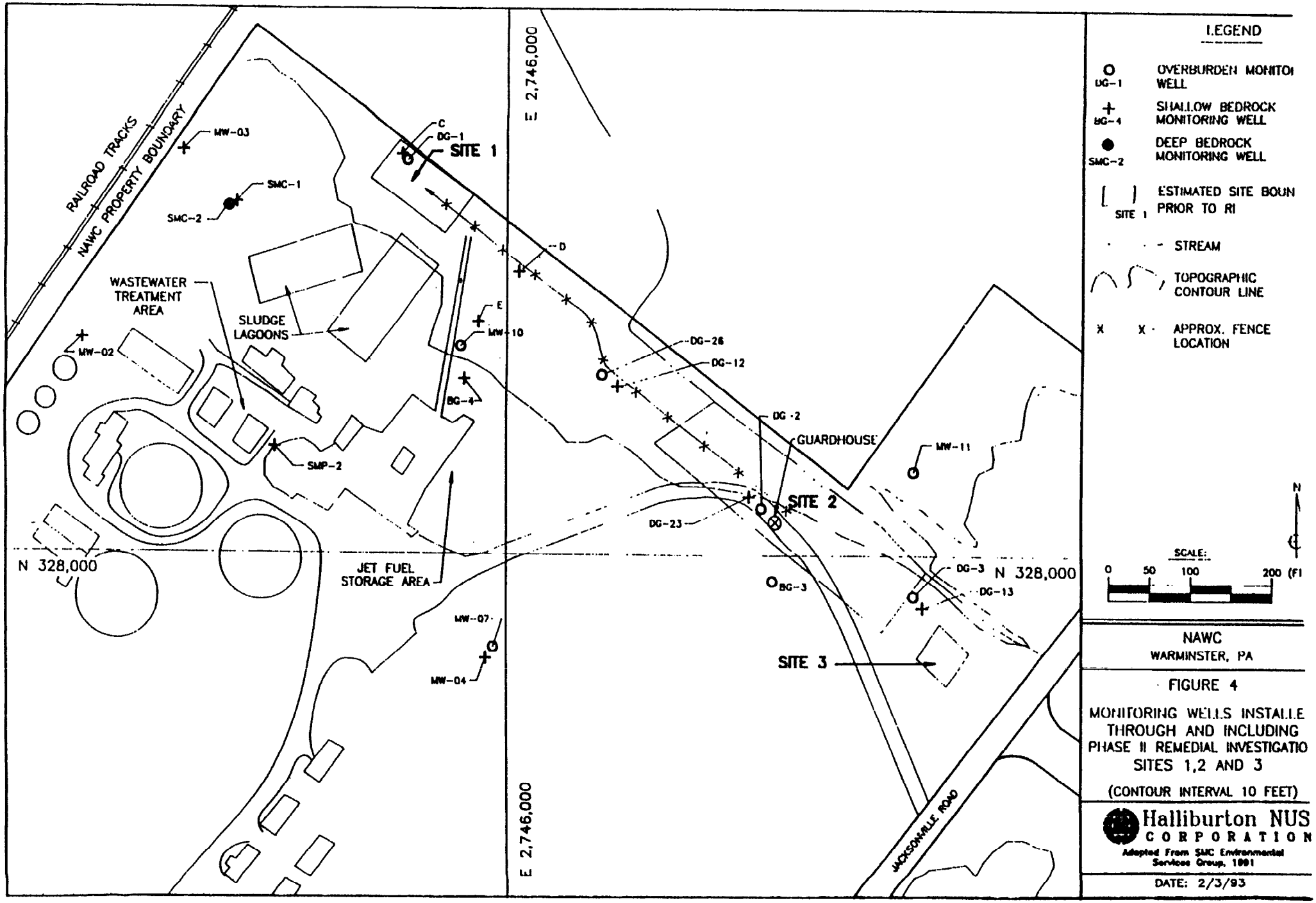
Adopted from - Halliburton NUS Corporation Phase II Remedial Investigation Report April 1993

TABLE 4
OCCURRENCE AND DISTRIBUTION OF FILTERED MONITORING WELL INORGANICS
SITES 1, 2, and 3
NAWC, WARMINSTER, PENNSYLVANIA
(ug/L)

Element	CRDL	Frequency of Positive Detection	Range of Positive Detection	Rep Conc
Barium	**200**	**13/13**	**29-343**	**210**
Calcium	**5000**	**13/13**	**30600-60700**	**51230**
Chromium	**10**	**1/13**	**31**	**9.6**
Iron	**100**	**6/13**	**37-4840**	**1860**
Lead	**3**	**3/13**	**1.6-5**	**1.86**
Magnesium	**5000**	**13/13**	**8750-21950**	**19150**
Manganese	**15**	**13/13**	**26-4190**	**1310**
Potassium	**5000**	**9/13**	**723-3360**	**2080**
Sodium	**5000**	**13/13**	**10400-40300**	**28140**
Vanadium	**50**	**1/13**	**6**	**3.39**
Zinc	**20**	**5/15**	**6-174**	**48.9**

CRDL = Contract Required Detection Limit

Adopted from - Halliburton NUS Corporation Phase II Remedial Investigation Report, April 1993


RAILROAD TRACKS
NAWC PROPERTY BOUNDARY
MW-03
SMC-1
SMC-2
C
DG-1
SITE 1
D
E
MW-10
WASTEWATER TREATMENT AREA
SLUDGE LAGOONS
MW-02
BG-4
SMP-2
DG-26
DG-12
DG-2
GUARDHOUSE
MW-11
SITE 2
DG-23
DG-3
DG-13
BG-3
N 328,000
JET FUEL STORAGE AREA
MW-07
MW-04
SITE 3
E 2,746,000
E 2,746,000
JACKSONVILLE ROAD
LEGEND
OVERBURDEN MONITOI WELL
SHALLOW BEDROCK MONITORING WELL
DEEP BEDROCK MONITORING WELL
ESTIMATED SITE BOUN PRIOR TO RI
STREAM
TOPOGRAPHIC CONTOUR LINE
APPROX. FENCE LOCATION
N
SCALE:
0 50 100 200 (FI
NAWC
WARMINSTER, PA
FIGURE 4
MONITORING WELLS INSTALLE THROUGH AND INCLUDING PHASE II REMEDIAL INVESTIGATIO SITES 1,2 AND 3
(CONTOUR INTERVAL 10 FEET)
Halliburton NUS CORPORATION
Adapted From SMC Environmental Services Group, 1991
DATE: 2/3/93
C:\DWG\NAWC\075

APPENDIX C

PUBLIC COMMENT LETTERS
ON
PROPOSED PLAN FOR OU-1A
AREA A GROUNDWATER

Pennoni
PENNONI ASSOCIATES INC.
CONSULTING ENGINEERS

One Drexel Plaza
3001 Market Street, Suite 200
Philadelphia, PA 19104-2897
Tel 215-222-3000
Fax 215-222-8568

Augurst 9, 2000

IVYL 0310.001.01

Mr. Lonnie Monaco
Naval Facilities Engineering Command (NAVFACENGCOM)
Northern Division
Environmental Contracts Branch, Mail Stop No. 82
10 Industrial Highway
Lester, Pennsylvania 19113

RE: Comments on behalf of Ivyland Borough
PRAP for OU-1A (Area A Groundwater)
Former NAWC Warminister

Dear Mr. Monaco:

Pennoni Associates Inc. ("Pennoni"), on behalf of Ivyland Borough, has reviewed the Proposed Remedial Action Plan ("PRAP") entitled *"Proposed Final Remedy for OU-1A, Extraction and Treatment of Area A Groundwater"*, dated July 2000. In addition, Pennoni reviewed the basis for the PRAP contained in the final *"Remedial Investigation/Feasibility Study Report for Area A Groundwater"* prepared by Tetra Tech NUS and dated June 2000. The Navy also issued a document entitled *"Operating Properly and Successfully (OPS) Demonstration"* for the Area A groundwater treatment system, prepared by Tetra Tech NUS, dated July 26, 2000. This document was reviewed for the most recent information concerning Area A groundwater quality. Based on our review of the above referenced document, we offer the following comments.

1. The PRAP is based on the hydrogeologic interpretation which describes hydrogeologic units A, B, and C as extending across Area A and continuing to Warminster Public Water Supply well No. 26. We concur that the zones may represent primary zones of groundwater movement and aid in interpretation of the movement of groundwater. However, we believe that the continuous. It is likely that fractures or other discontinuities provide local pathways for migration of water and contamination between units which may not be reflected in the measured head differential between wells screened in the different intervals. This possibility needs to be considered in the evaluation of the performance of the selected remedy.

2. The Navy has issued an Operating Properly and Successfully ("OPS") determination for the existing groundwater treatment and extraction system before the public comment period or a Record of Decision was complete. This is premature from both a procedural and technical standpoint. From a procedural point of view it indicates that the Navy is already convinced that the remedy is adequate and sufficient without giving any consideration for the possibility that the public input may indicate otherwise. From a technical point of view the OPS determination is based upon less than one year of data which provides a very limited data base for predicting long term performance. For comparison, the OPS for the Area C groundwater extraction and treatment system was issued almost four years after implementation of the remedy.

3. The Navy states that some of the groundwater contamination is attributable to off-base sources. Since none of these alleged sources have been identified or delineated, we are concerned that portions of the contaminated plume which originated at the bass will not be considered part of the remedy because of the Navy's belief that the the plume is co-mingled (i.e., blended) or originated elsewhere. Presently, there is insufficient evidence to determine the nature of the Oledged off-site sources and additional investigation and long term monitoring will be required to define the plume,

4. Some of the contamination which the Navy attributes to a potential off-site source is in the vicinity of well HN-50S which is north of the Robensack well in Ivyland. However, the Wagner well was pumping for many years with consistently elevated levels of TCE. Although the Wagner well is no longer pumping, the influence of the well in drawing a portion of the plume into Ivyland needs to be evaluated based on long term monitoring and the results in HN-50S may reflect that effect

5. The PRAP and the RI/FS does not address the risk to residents of Ivyland who are connected to public water but who still use their wells for filling their swimming pool or watering their lawn. These risks should be addressed in selection of a remedy.

6. The Remedial Investigation (RI) report and the OPS determination both calculate relatively short clean-up times (i.e., less than 11 years) for the portion of the contaminant plume outside the Technical Impracticability (TI) waiver zone where the Dense Non-Aqueous Phase Liquid (DNAPL) is present. The clean-up times seem overly optimistic and a rate calculation using the May and June data for the downgradient wells indicates a longer time to remediate the groundwater to safe levels.

7. The PRAP states that the contaminant plume downgradient of the capture zone of the extraction well network is captured and treated by Warminster Authority Well 26. For the Navy to conclusively determine that Well 26 is capturing all of the plume, monitoring wells need to be installed downgradient of Well 26 to the depth of concern and sampled on a regular basis.

8. The PRAP and the Feasibility Study report describes an Alternative 3 which includes off-base extraction wells. The Navy has selected Alternative 2 which includes the existing extraction well network and EW-18. We believe that the remediation of the off-base portion of the plume will take longer than the Navy projects. Because of the complex nature of fractured bedrock, there may be portions of the plume which will not be remediated in a timely manner through operation of the current system. Therefore we believe that Alternative 3 be added to the ROD as a contingent remedy to be implemented in the event that furure monitoring shows inadequate restoration of the groundwater aquifer.

If you have any questions, please do not hesitate to contact us.

Very Truly Yours,

PENNONI ASSOCIATES, INC

J. Anthony Sauder, P.E., P.G.
Senior Hydrogeologist

Kevin J. Davis, P.E.
Associate Vice President

cc: Herb Carver, Manager - Ivyland Borough
Robert Servern, President - Ivyland Bourgh Council
Greg Stern, Esquire - Harris & Harris

Pennoni
PENNONI ASSOCIATES INC.
CONSULTING ENGINEERS

One Drexel Plaza
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Fax 215-222-8568

August 9, 2000

WARM 9608.002.01

Mr. Lonnie Monaco
Naval Facilities Engineering Command (NAVFACENGCOM)
Northern Division
Environmental Contracts Branch, Mail Stop No. 82
10 Industrial Highway
Lester, Pennsylvania 19113

RE: PRAP for OU-A (Area A Groundwater)
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1. The PRAP is based an the hydrogeologic interpretation which describes hydrogeologic units A, B, and C as extending across Area A and continuing to Warminster Public Water Supply well No. 26. We concur that the zones may represent primary zones of groundwater movement and aid in interpretation of the movement of groundwater. However, we believe that the confining layers between these areas should not be assumed to be continuous. It is likely that fractures or other discontinuities provide local pathways for migration of water and contamination between units which may not be reflected in the measured head differential between wells screened in the different intervals. This possibility needs to be considered in the evaluation of the performance of the selected remedy.

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If you have any questions, please do not hesitate to contact us.

Very Truly Yours,

PENNONI ASSOCIATES, INC.

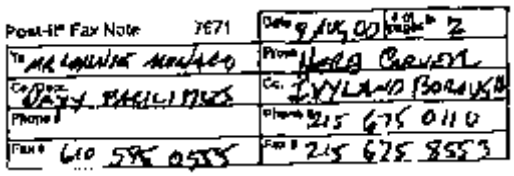
J. Anthony Snyder, P.E., P.G.
Senior Hydrogeologist

Kevin J. Davis, P.E.
Associate Vice President

Cc: Robert Camarata, Warminster Township

Borough of Ivyland

710 Ivyglenn Circle, Ivyland, PA 18974 C
215-675,0110 C FAX. 215-675-8553



09 August 2000

Navy Facilities Engineering Command
Northern Division
10 Industrial, Mail Stop #82
Lester, PA 19113-2090

Attn: Mr. Lonnie Monaco fax: 610 595-0555

Subject: Community Comments regarding the Proposed Plan for Area A groundwater

Dear Mr, Monaco,

Below is a summary of comments and concerns express at the Ivyland Borough Council Meeting on 02 August 2000:

1. Regarding the selection of Alternative 2 vs, Alternative 3:

1.1 What is the projected number of years respectively for the alternatives to restore Area
A groundwater outside of the TI zone to useable standards?

1.2 What will be “useable standards”?

1.3 When extracting 600 pounds vs. 150 pounds of compounds per year, would this imply
that “useable standards” could be achieved four times quicker?

1.4 Because the Alternative 2 treatment has already begun, is the Capital Cost already included in Alternative 2 30-year NPW? If so, what is the Capital Cost already included in Alternative 2 30-year NPW and for what uses? What is the anticipated Capital Cost included in Alternative 3 30-year NPW? What are the projected Operation and Maintenance Cost each year respectively for both alternatives?

1.5 Is the “potential for exposure . . . . . .” in evaluating Alternative 3 REALLY a strongreason to be mentioned for consideration in evaluating the choice of alternatives? Is Alternative 3 going to expose construction workers to any greater potential levels of contamination than has been experienced throughout the NADC cleanup process?

2. Regarding implementation of Alternative 2 or 3:

2.1 Both Alternative 2 and 3 intend "to limit exposure to contaminated groundwater" through Institutional Controls. In general, what are Institutional Controls? How are they instituted? Do they require legal/legislative action by Ivyland Borough? How are they enforced? What are anticipated costs to implement Institutional Controls? Who pays for these costs? Specifically, what Institutional Controls are proposed for Ivyland Borough? Do they apply only to a portion of the borough that is exposed to contamination above a certain level?

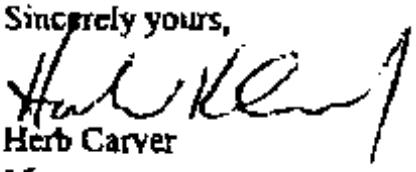
2.2 The mechanics of Alternative 2 are essentially in effect now by use of an extraction, treatment, discharge system. Where exactly is the "unnamed tributary of Little Neshaminy Creek" located? Where is the point of discharge? How often is the treated discharge monitored for contamination? What are the acceptable levels of contamination to allow continued discharge?

2.3 The mechanics of Alternative 2 or 3 require components of the system to be located "off-base". We understand that a parcel of land in Ivyland Borough, immediately adjacent to the TI zone, has recently been purchased by the Navy. Also, several new monitoring and/or extraction wells and associated piping are now located in Ivyland Borough generally between the purchased property and the railroad tracks. Has the Navy placed and restrictions on, or requested any special uses to enable the Navy to access these "off-base" facilities located within neighboring municipalities? Should neighboring municipalities be officially notified in writing from the Navy about any restrictions or special uses on private property within the municipality?

3. Private wells were the primary source of drinking water until the 1970's when municipal water became a available in Ivyland Borough. Concerns of long term health risk from possible exposure to contaminated groundwater from the 1940's through the 1970's has been raised by residents. What information is available regarding the kinds and levels of contamination in Ivyland Borough groundwater from the 1940's through the 1970's? What health risks are associated with consumption of well water under such circumstances?

Thank you for your consideration.

Sincerely yours,



Herb Carver
Mayor

cc: Ivyland Borough Council, attn.: Robert Severn, President
Greg Sturn, Borough Solicitor

Borough of Ivyland

710 Ivyglenn Circle, Ivyland, PA 18974 C 215-675,0110 C FAX. 215-675-8553

August 7, 2000

Mr. Lonnie Monaco
Northern Division
Naval Facilities Engineering Command
10 Industrial Highway, Mail Stop #82
Lester, PA 19113-2090

Dear Mr. Monaco,

I am writing on behalf of the Inyland Borough Council and the residents of Ivyland Boroung. I myself am a resident of Wilson Ave. for the past thirty years. When I first moved to the Borough, most of the residents' water came from wells located on their properties. In light of the reports concerning the groundwater contamination on the former NAWC and the efforts by the Department of the Navy to clean up these areas, I am interested in knowing what implications there may be to residents who could have been exposed to these contaminants in the years before the current studies and results were made available to the public.

Thank you in advance for any information you can send me regarding this matter.

Sincerely,

Janet Pacchioli, Ivyland Borough Secretary

Earth Data
INCORPORATED
GROUND WATER AND ENVIRONMENTAL CONSULTANTS
ST. MICHAELS, MARYLAND AND EXTON, PENNSYLVANIA

August 8, 2000

Mr. Lonnie Monaco
Northern Division
Naval Facilities Engineering Command
10 Facilities Highway, Mail Stop #82
Lester, PA 11913

Subject: Former Naval Air Warfare Center, Warminster, Pennsylvania
Comments on Proposed Plan for Final Remedy for Operable Unit (OU-1A)
Extraction and Treatment of Area A Groundwater

Dear Mr. Monaco:

The Warminster Township Municipal Authority (WTMA) has reviewed the above-referenced Proposed Plan and the Remedial Investigation/Feasibility Study (RI/FS) report which provides the technical basis for the preferred alternative. This letter represents WTMA's formal comments for purposes of the Adminstrative Record and will supplement other comments, oral and written, submitted to the United States throughout the RI/FS and Proposed Plan development process.

For the record, WTMA received a copy of the Draft RI/FS to the Navy on June 13, 2000. WTMA submitted detailed written comments on the Draft RI/FS to the Navy on June 13, 2000. WTMA was not provided an opportunity to comments on the final RI/FS. WTMA received a fraft version of the Proposed Plan on July 6, 2000. WTMA submitted detailed written comments on the proposed plan the very next day, July 7, 2000. However, WTMA was advised by the Navy that the Proposed Plan was finalized by the Navy and was sent to the printers before WTMA's comments were received. As a result, WTMA's comments were not included in the version of the Proposed Plan which was issued to the public.

The following summarizes WTMA's comments on the RI/FS and the Proposed Plan:

(1) WTMA is one of the oldest water companies in Bucks County, Pennsylvania. Established in 1953, WTMA's supply comes entirely form the groundwater resources of the Stockton Formation. To date, WTMA has drilled approximately forty-six exploratory wells in the Stockton Formation. The hydrogeological data base resulting from WTMA's groundwater exploration and development activities in the Stockton Formation is extensive. As a result of the Navy's contamination of WTMA's Well 26, WTMA has

more than 20 years direct experience with groundwater contamination with Volatile Organic Compounds. WTMA does not concur with the Navy's interpretation of the characteristics of the Stockton Formation underlying Area A. The Navy's interpretation purports that there are uniform, laterally extensive mudstone units underlying Area A, which are unique to Area A, which act as barriers to vertical groundwater flow and the downward migration of contaminants.

WTMA does not believe that the data presented in the RI conclusively identifies these units. Further, the importance of these units is overemphasized. As described in the RI, these low permeability units most closely match the description of an aquitard.[1] The RI acknowledges the presence of dense, non-aqueous phase liquids (DNAPL's) in Area A. Ctirrent scientific research conducted at DNAPL sites worldwide shows that many (if not most) silty or clayey aquitards commonly contain fractures or other openings which allow DNAPL's to move through them, thereby causing contamination of underlying aquiilers.[2]

The RI presents 1997 groundwater sampling data which shows that four of six wells sampled from Hydrogeologic Unit C contained Trichloroethylene (TCE) which exists as a DNAPL in Area A. This sampling event preceded the installation of the onsite extraction wells which occurred in the December 1998-March 1999 time frame. The RI also presents the results of the June 1999 groundwater monitoring which was performed to establish baseline groundwater quality conditions within Area A prior to the startup of the extraction weIls. No wells from Hydrogeologic Unir C were sampled and no explanation is provided. This circumstance raises additional questions regarding the Navy's interpretation given that unsealed or improperly sealed borcholes are common vertical pathways for DNAPLs.

(2) The RI/FS states that contamination patterns off-site and downgradicnt of Area A indicate the presence of other sources of contamination not related to NAWC Warminster. This is not a new theory. In fact, the Navy first put forth this hypothesis in 1984.[3]

For the record, for some time now, EPA has been performing its independent assessment

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[1] *Dictionary ofGeologic:al Terms, Bares and Jackson, 1984*

[2] *Dense Chlorinated Solvents and other D)VAPLv in Groundwater, Pankow & Cherry, 1995*

[3] *Final Report on the Groundwater Monitoring and Hydrogeologic Investigation for the Naval Air Development Center, Warminster, Pennsylvania. Walter B. Sattechwaile Associates, Inc., 1984*

of potential offsite source area To date. none have been identified.

Further. the data in the RI/FS raise questions about the Navy's hypothesis.

First, the statement in RI/FS referring to the absence of PCE and 1,1,1 TCA in Area A is misleading. One of the principal findings of sampling performed in 1990 by SMC-Martin was the detection of PCE, TCE. 1,1,1 TCA in two monitoring wells SMC-1 and SMC-2 installed at the site of the Navy's old sludge lagoons. Additional information about the detection of PCE and 1,1,1 TCA in Area A is provided in the *Stage I and II RI Report* prepared by SMC Environmental Services Group in April. 1991. One of the conclusions of this report was that TCE. PCE, chloroform. carbon tetrachloride and 1,1,1 TCA originate from onsite sources of contamination.

Second, the conclusion that the contamination in HN-52 originates from an oftsite source is inconsistent with the following interpretation taken from the Navy's own *Draft Area Aloffifte Water Level Study*. "The groundwater flow maps do not show groundwater migrating directly from the on base area of greatest groundwater impacts (Site 1 located in the HN-11 area) to WMA 26 under pumping and non pumping conditions encountered. From the Site 1 area , groundwater appears to migrate towards cluster-HN 52. Given the pronounced strike parallel drawdown pattern observed in the aquifer through comparison of water levels obtained during pumping and non pumping conditions (Figure 3-2), however, the water level data indicates that an extended capture zone exists for WMA 26 along strike of the geologic units and is probably large enough to capture groundwater migrating through the HN-52/HN-65 areas".

WTMA believes that rpost of contamination in HN-52 originates in Area A. The technical data regarding possible off size contributors is insufficient to support the Navy's theory.

(3) WTMA questions the technical basis to support the conclusion that groundwater pump and treat will eventually remediate contaminated groundwater downgradient of the TI zone, to comply with chemical specific ARARS such as MCL's. Historically, pump and treat has had very limited success in restoring fractured media contaminated with DNAPL compounds to health based levels, which is the documented condition in Area A.

(4) Groundwater contamination was first detected at NAWC Warminster in 1979. In its May 1992 mernorandurn entitled "*Considerations in Groundwater Remediatiop, at Superfund Sites and RCRA Facilities,* EPA recommended early action to prevent or minimize the farther migration of contaminants particularly in situations involving DNAPL. Despite this. it still took the Navy an additional seven years to implement the interim groundwater remedy. As a result, contamination attributable to the Njivy migrated offsite. WTMA

believes that there is insufficient monitoring data to demonstrate that the interim system, which has been in more or less continuous operation for about one year, creates a capture zone which encompasses the on base portion of the plume. Further, XWMA believes that additional monitoring data (both onsite and offsite) is needed to adequately support an Operating Properly and Successfully (OPS) Demonstration.

(5) WTMA objects to the Navy's selection of Alternative,#2 over Alternative #3 as the preferred alternative on the basis that Alternative #3 would be "far more difficult to implement". In WTMA's view, the Navy's preference appears to be based solely on the Navy's position that it need not address aggressively the plume(s) of contaminated groundwater attributable to the Navy which extend downgradient of the capture zone and which are captured and treated by WTMA Well 26. because of the possibility that other off-site sources may thereafter corruningle with the Navy's plume. In WTMA's opinion, there is no legal basis or justification for such a position in CERCLA despite the Navy's claim to the contrary tliat federal facilities as polluters are not under the same obligation as are private parties insofar as commingled plumes of contamination are concerned. The Navy's remedial plans should not assume that the Navy's obligation to aggressively remediate off-base contamination can be allocated on a molecule by molecule basis. Not only is such an approach technically unsound, but it is bad public policy, particularly where, as here, the offsite recipient of the plume is a public water supply well. At this point, the technical data regarding possible off-site contributors is simply insufficient to support the Navy's commingling theory, at least insofar as contributions to WTMA Well 26 are concerned. The fact that the Navy may have a contribution action against any third parties ultimately found responsible for some of the contamination does not, and should not influence the selection of the best or most protective remedial approach when a public's water supply is at stake. The Navy must take a more aggressive position on its remediation, regardless of how a court ultimately may decide to allocate shares of the remedial cost.

It is technically unsound, legally inadequate, and inconsistent with the NCP, to espouse or imply in the RI/FS, or the Proposed Plan that less rigorous investigation or remediation of off-site components of the Navy's plume, by the Navy, is appropriate because of the potential that other off-site sources may be contributing to, and commingling with haza dous substances released by the Navy. If offsite plume concentrations attributable to the Navy warrant xemedial action, (and they do) then remedial action should be taken now, by the Navy - it should not be put off to some unspecified future date when, presumably, someone will have more data on which TCE molecules originated on the Base and which originated somewhere else. In the absence of remedial action. the Navy is, in effect and through a refusal to act, determining that the public health and environmental risks of plume migration are inconsequential, a public decision that is without support in the empirical data.

(6) Finally, the Authority believes it is inappropyiale to formally "Select" as a CERCLA remedy use of Authority Well No. 26 as a plume containment/reinediation system for the release or threatened release of hazardous substances from NAWC-Warminster.

Although it has been recognized that Well No. 26, an active municipal supply well, is impacted by the release of hazardous substances from NAWC-Wanninster. and the Authority runs a treatment system on the well to protect health and safety, its operation of Well No. 26 should not be coopted through federal action as a remedial system operated for the benefit of the United States. Any benefit the United States obtains through the Authority's operation of Well No. 26 is. purely, incidental to the Authority's pre-existing operation of Well No. 26 for public water supply purposes. The Authority is very concerned that the public, among others, will wrongly perceive such a declaration in The PRAP and ROD as a determination that the Authority or the United States are mmediating contamination migrating from NAWC-Warminster by delivering it to the public through the operation of the water supply system. At most, the PRAP and ROD should recognize that plume migration from the areas in question is not being addressed because existing systems provide the incidental benefit of containing plume migration. The ROD could state, for example, that should the Authority discontinue operation of Well 26 for public water supply purposes, a determination would need to be made regarding the use of that well or a different withdrawal well to enhance the Navy's capture or containment of contaminants that may have migrated from the base. But formal statements indicating that operation of Well No. 26 is part of the formal selected remedy and one component of the remediation system designed for the Base is inappropriate and ill-advised. The ROD also should document the fact that the United States will continue to work with the Authority to monitor Well No. 26 to be sure that water being extracted at that point does not pose any unreasonable risk to public health and safety.

Sincerely,

W. David Fennimore

W. David Fennimore, P.G.
Senior Hydrogeologist/Vice President

cc: G. Smith-WTMA
A. Ferdas-EPA
D. Ostraiskis-EPA
A. Flipse-PADEP
J. Burke-PADEP
T. Sauder-Pennoni
B. Nemeroff-J.F.S.N. & A.
T. Bergere-M.M.W. & R.